THE

# INTERNATIONAL ENCYCLOPÆDIA

OF

# SURGERY.

VOL. III.

THE

# INTERNATIONAL ENCYCLOPÆDIA

OF

# SURGERY

## A SYSTEMATIC TREATISE

ON THE

## THEORY AND PRACTICE OF SURGERY

BY

AUTHORS OF VARIOUS NATIONS



EDITED BY

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ILLUSTRATED WITH CHROMO-LITHOGRAPHS AND WOOD-CUTS

IN SIX VOLUMES

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# PREFACE.

The Third Volume of the Encyclopædia resumes the consideration of the Injuries and Diseases of the Various Tissues of the Human Body, containing separate articles on Injuries and Diseases of the Muscles, Tendons, and Fasciæ; on Injuries and Surgical Diseases of the Lymphatics; on Injuries of Bloodvessels; on Surgical Diseases of the Vascular System; on Aneurism; on Injuries and Diseases of the Nerves (including Tetanus); and on Injuries of the Joints.

In the three important articles devoted to the Surgery of the Bloodvessel System, there has been, of necessity, some overlapping. Thus, in the consideration of the operations practised upon arteries, Dr. Lidell, as is fitting, has considered these from the point of view of the Army Surgeon, called to treat hemorrhage from a wounded but otherwise normal vessel, while Mr. Barwell has dealt with the subject as it presents itself to the Hospital Surgeon in Civil Practice, who in operating for the cure of aneurism is concerned with arteries which are themselves diseased, and which are often widely displaced from their natural positions. Each account of the subject is valuable in itself, and each is essential to the unity and completeness of the article in which it appears.

In bringing to a conclusion his work upon the Third Volume of the Encyclopædia, the Editor has to lament the death of one of his most distinguished and most valued collaborators, the late Prof. William H. Van Buren, of New York. A wise surgeon, a skilful operator, an accomplished teacher, a learned and elegant writer,

a faithful friend, and an honorable, high-minded gentleman, Van Buren worthily represented the best type of American Surgeon. His admirable study of Inflammation—destined to be classical in Surgical Literature—in the First Volume of the Encyclopædia, was his last contribution to the science of that profession which he loved so well, and of which he had been so long an ornament and most honored member.

The Editor feels confident that the present volume will fully sustain the high reputation acquired by its predecessors—translations of which into both the French and Italian languages have already been announced—and that on account both of the importance of the subject matter of its several articles, and of the exhaustive, and at the same time eminently practical manner in which these have been dealt with by their respective authors, it will be received with equally gratifying commendation. The thanks of both the Editor and Publishers are due to the Surgeon-General of the U. S. Army, for his kind and liberal permission to use a number of illustrations from the Medical and Surgical History of the War of the Rebellion, as they are also for similar courtesies received from Prof. Esmarch, the late Prof. Sédillot, Prof. Bigelow, and Dr. Weir Mitchell.

JOHN ASHHURST, Jr.

Philadelphia,
2000 West Delancey Place,
April, 1883.

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# THE INTERNATIONAL

# ENCYCLOPÆDIA OF SURGERY.

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# THE INTERNATIONAL ENCYCLOPÆDIA OF SURGERY.

## INJURIES AND DISEASES OF THE MUSCLES, TENDONS, AND FASCIÆ.

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### Injuries and Diseases of the Muscles.

In common with other systems of the body, the muscular is the seat of various injuries and diseases; though in virtue of its anatomical construction, its protection by overlying fasciæ, fat, and skin, and its inherent power of resistance to morbid impressions, such lesions and affections are much less frequently met with than might naturally be expected, taking into consideration the number and size of the muscles and their exposed situation.

Myalgia.—With a painful state of varying intensity and duration, affecting one or more muscles, every one is familiar. Affecting most frequently the muscles of the neck, of the back, of the chest, and of the calf of the leg, this muscular pain or *myalgia* may be consequent upon strain or limited rupture, upon disease in or about the vertebral articulations, upon nerve-pressure, upon a general or special febrile affection, upon particular poisons, such as those of syphilis or lead, or upon rheumatism or gonorrhœa; muscle-pain being the one constant symptom common to all these conditions. Unquestionably neuralgic in nature in the majority of cases, in some if not all of the rheumatic and gonorrheal attacks it must be inflammatory, since myositic hyperplasias, atrophies, and contractures do at times follow. Recognition of the existence of the pain being perfectly easy, from either the difficulty or impossibility of movement, from the existing muscular spasms, from the facial expression, or from the believed reliability of the patient's statements, it is of chief importance to determine the cause of the myalgia, in order that, this being removed, the effect may cease, as it generally does when it is

possible by therapeutic or operative measures to get rid of the primary trouble. The use of heat, electricity, anodynes or anæsthetics may be required for the prompt relief of the pain.

Ruptures of Muscle.—Laceration of muscular fibres may be consequent upon either blows from without or the force of the muscle's own contraction; may vary in extent from the slightest tearing, hardly more than simple stretching, to complete pulpification; may be recovered from speedily and perfectly, or may terminate in destruction of the part or even in loss of life. When the result of contraction, this in a healthy state of the tissues is never, or almost never, voluntary; but is a sudden violent movement of a muscle, off its guard, as it were, and unsupported by its associates. When, however, because of existing general disease the muscular fibres have undergone such changes as render them in a high degree brittle (the granular or vitreous degeneration), rupture not infrequently takes place in consequence of volununtary movements even of slight amount. Such an accident is most often met with during the later stages of typhoid fever, but it has also occurred in cases of scarlet fever, yellow fever, and other acute, grave pyrexias; the muscles most frequently damaged are, in the order of relative frequency, the rectus abdominis, the rectus and adductors of the thigh, the gastrocnemius and soleus, the psoas, and the flexors of the forearm. External violence may cause rupture of any of the superficial muscles, and, at times, undoubtedly of some of those which lie more deeply.

*Symptoms.*—The occurrence of muscular rupture is indicated in typical cases by sudden, sharp pain, accompanied with the sensation of a snapping in the injured region; by characteristic deformity, a well-defined depression—not infrequently, indeed, a wide gap—existing at the place of rupture, with decided swelling above; by extravasation of blood, indicated by swelling and color-changes in the skin, coming on early or late according as the torn muscle is near to or remote from the surface, and varying in amount from the slightest effusion to one of such extent as to constitute a veritable hæmatoma; and by impairment of function, the ability or inability to move the part supplied by the injured muscle depending upon the extent of the laceration. While all these symptoms may be and generally are found more or less clearly manifested in cases occurring in healthy individuals—certainly in all cases of complete rupture of an external muscle—they very often will not be recognized in cases of laceration occurring in the progress of general diseases, unsuspected rupture of large and important muscles being not infrequently discovered upon post-mortem examination.

*Secondary Effects of Muscular Rupture.*—The effects produced by these injuries will depend upon the muscle affected and the extent of its damage. Slight lacerations will be completely recovered from; and more extensive, or even complete separations, especially of the muscles of the extremities, will usually be followed under proper treatment by little impairment of functional integrity. When one of the abdominal muscles, especially the rectus, is extensively damaged, intestinal obstruction simulating strangulated hernia, or peritonitis, may be developed, and the latter, if not terminating fatally, may cause fixation of a part of the intestinal tube to the abdominal wall.

Treatment.—In the management of muscle-rupture, as in the analogous injury of bone (fracture), the essential principles of treatment are the putting the parts in apposition and then keeping them there. The difficulty in accomplishing these desired objects lies in the retractibility of the tissue damaged, this not only causing wide separation at first of the divided ends,

but rendering it difficult, oftentimes impossible, to produce any close approximation, or to maintain it, if secured; still, by rest, position, and appropriate bandaging, with the plaster-of-Paris or the elastic-rubber bandage rather than the ordinary roller, much may be done. Cutting down upon the torn ends and suturing them either with wire or catgut has been advised. Union, which, unless there has been extensive extravasation of blood or suppuration, may be expected, is ordinarily effected by means of an interplaced connective-tissue band, of length dependent upon the degree of retraction. Occasionally, as in rare cases of wound, perfect anatomical as well as functional repair takes place, the new muscular elements being developed either from the cellules on the inner surface of the sarcolemma, the connective-tissue corpuscles of the perimysium, or the migrated white corpuscles; or, as is not at all improbable, from all three sources.

Wounds of Muscles.—These may be either subcutaneous or open, and, like ruptures, are attended with retraction and hemorrhage, symptoms which are, as a rule, much more marked in the open than in the subcutaneous variety. While the subcutaneous wounds are ordinarily injuries of but little moment—the extravasated blood being rapidly absorbed, little or no inflammation occurring, and early and very satisfactory repair taking place—the open ones are lesions of very much more importance, the large gap between the divided ends (all the larger because of the free division of the sheath) filling up only through granulations, and the resulting connective-tissue cicatrix very imperfectly substituting the original muscular fibres. As the effects of wounds resemble those of rupture, so the *treatment* is much the same—rest, compression, and approximation as close as possible of the divided ends. In the open wound such approximation can never be very close, and any attempt to increase it by the use of sutures is apt to result in failure, owing to the strong probability of an early tearing-out of the stitches, because of the inflammatory changes produced in the fibres even at some little distance from the wound.

Hernia of Muscle.—Consequent upon the presence of an abnormal opening in the investing aponeurosis, muscular protrusion may take place; such an opening being the result of a laceration, at the time of a sudden, violent muscular action, or of a wound (as from the passage of a bullet) not followed, as it ordinarily is, by complete union, but by cicatricial rounding off of the edges. These herniæ when suddenly produced are generally associated with acute myositis, and, whether slowly or rapidly developed, with decided impairment of the functional integrity of the affected muscles.

*Diagnosis.*—Muscular herniæ may be confounded with muscular ruptures—in certain locations, with intestinal herniæ—with blood-tumors, or with abscesses. The diagnosis is ordinarily, however, not difficult. There is noticeable a marked fulness at the time of muscular contraction, disappearing when relaxation takes place, such fulness being more or less firm to the touch according to the degree of muscular development. In the acute cases all movement of the injured parts is painful, in many cases so painful that the use of the muscle is for the time being abolished. When the opening has long existed it can usually be readily detected upon pressure, and if while the finger is kept upon it contraction of the underlying muscle is brought on, the fibres can be felt swelling up into the aperture.

The *treatment* in acute cases consists in rest and methodical pressure, which usually will secure closure of the opening; failing to effect such, the edges of the fascial laceration must be freshened and united by sutures. In old-standing cases this is the only way in which a cure can be effected. In the

majority, though, of these accidents the inconvenience to the individual is so slight that either nothing need be done, or a simple retentive bandage may be applied so as to limit the degree of protrusion.

Inflammation of Muscle.—Primary myositis, not dependent upon injury, contiguous inflammation, diathetic conditions, or parasites, is exceedingly rarely met with. Indeed, it is with many a question whether such idiopathic inflammation can ever take place; and it is agreed that muscular tissue is of all in the body least liable to spontaneously take on inflammation. There are cases met with, however, in which, as is supposed, in consequence of exposure to cold or of excessive use, a muscle-inflammation occurs, presenting the ordinary symptoms of such pathological conditions, and characterized by a peculiar firmness along the course of the muscle, the "woody-hardness" of Velpeau. Such inflammation may terminate either in resolution, which is most usual, or in sclerosis, or, which comparatively seldom occurs, in suppuration.

*Traumatic myositis* is frequently met with, much more so in men than in women, on account doubtless of their greater exposure to the action of the developing causes. It gives rise in greater or less degree to pain both on pressure and movement; to limited swelling, the outline of which corresponds to the muscular contour (such swelling being chiefly due to effusion and exudation, but in part at times to extravasation of blood); and to interference with or entire arrestation of the functional action of the affected part; with associated heat, redness, and it may be ecchymoses in the overlying skin. As a rule, such muscle-inflammation is of little importance, being but one of many pathological conditions resulting from the causative injury, and usually disappearing without any treatment other than that proper for the relief of the general effects of the accident. In this, as in the very much rarer idiopathic form of myositis, suppuration seldom takes place (except when the psoas is the muscle affected, in which case it is almost certain to occur); and when it does, such occurrence will generally be found to be due to a predisposing, cachectic condition of the patient, with perhaps an unusually large extravasation of blood.

In most cases such suppuration is readily recovered from, either with complete muscular restoration, or with the formation of the ordinary connective-tissue cicatrix. At times, however, more often in badly-nourished subjects, but sometimes in the robust, a diffuse inflammation of very grave character is met with, affecting few or many muscles, and very analogous to acute osteo-myelitis and acute phlegmonous periostitis. This "muscular typhus," which is generally, if not always, of septic origin, and in which the diseased muscles rapidly break down and septicæmic conditions are early manifested, is, if left to itself, almost necessarily mortal, and the fatal result can be averted at the best only by early and free incisions, and the consequent prompt evacuation of pus and separation of the necrosed tissue.

Differing from this in its localization and in the less dangerous constitutional symptoms which result, is the acute necrosis of a single muscle or an associated group of muscles; as in the case reported by Lücke, in which, following a fall which produced no pain nor apparent extravasation, the whole mass of muscles on the antero-external surface of the leg perished, in consequence, as the reporter believed, of embolism of the supplying artery, though such an explanation may well be questioned, since the pulsation of the dorsalis pedis artery remained unaffected throughout.

Occasionally the myositis is a chronic one, swelling with associated "woody" hardness being ordinarily the only symptom present. When not consequent upon inflammation of contiguous joints or bones, most of these slowly-

developed inflammations are of syphilitic origin. Not so very rarely there are met with, most usually in so-called scrofulous subjects, *cold abscesses*, single or multiple, varying in size, but never very large, easily to be felt in the substance of the muscle, and because of their firmness and the absence of all inflammatory symptoms often mistaken for muscle-tumors. When by the coalescence of several of the originally separated abscesses a single and rather large one is formed, a well-defined limiting pyogenic membrane will be found to exist.

CONTRACTURES.—As a result of the connective-tissue sclerosis, muscular shortenings occur, with produced deformities of varying degree and permanency. The hardened and contracted belly of the muscle can easily be felt, and neither actively nor passively can full extension be secured. When treatment is early instituted, restoration of the muscle to its functional integrity often takes place, but when the diseased condition has long existed, the muscle is, ordinarily, irreparably damaged, and either myotomy or tenotomy will be required before the resulting deformity can be corrected. In the "late rigidity" associated with paralysis of cerebral origin, the flexors of the upper extremity being the muscles especially affected, the contracture may be expected to be permanent. Rest, frictions, methodical massage, stimulating applications, and electricity, are each and all of service in promoting the cure. As will hereafter be seen, many of these conditions are of syphilitic origin, and to be relieved only, if at all, by the use of mercury and the iodides.

All muscular contractions are not dependent upon inflammatory sclerosis. They may be rather apparent than real, as when the opposing muscles are paralyzed. Oftentimes they are reflex in origin and protective in character, as is constantly seen in the case of the rigid muscles about an inflamed joint; though in such cases the contractions frequently become real in course of time from degenerative changes following the abnormal approximation of the two ends of the muscle. Such rigidity, as of the adductors in morbus coxarius, and of the erector spinæ in vertebral caries, is not infrequently the earliest symptom noticeable, and its detection should always lead to a very careful examination of the neighboring joint or joints. Though for a considerable length of time these reflex contractions are dependent upon nerve irritation, and the muscle remains perfectly healthy, yet, if long-continued, inflammatory and degenerative changes occur, and contracture takes the place of contraction—the active yielding to the passive state. In hysteria, contractions, lasting sometimes for years and then disappearing, it may be suddenly, are met with; and the cutting off of the blood-supply may give rise to contractions much akin to post-mortem rigidity.

HYPERTROPHY OF MUSCLE.—Increase in the size of a muscle may be real and due to the formation of new muscular elements or enlargement of those already existing, or may be apparent and consequent upon the presence of fat, connective-tissue hyperplasia, or excessive development of the lymphatics and bloodvessels. It may be congenital or acquired, limited or general, symmetrical or unilateral. Not infrequently, as in various classes of workmen, it can be directly traced to disproportionate use of the affected muscle or muscles, and in certain pathological conditions, as in cardiac hypertrophy, and in the thickened bladder walls associated with prostatic enlargement, it is compensatory and salutary. At times the muscular overgrowth is associated with equal or greater increased development of bone, fasciæ, and skin; in other words, the whole affected region is hypertrophied. Reduction in size of the hypertrophied muscle may often follow diminished functional activity, or

rest, as absolute as may be, aided by compression. In hypertrophy of the tongue, partial ablation is at times required. Macroglossa, however, is very rarely due to actual increase in number and size of the muscular fibres, but generally to great over-growth of the lymphatics and bloodvessels of the part, with more or less hyperplasia of the connective tissue.

A few cases have been observed of "progressive muscular hypertrophy of adults" (Benedikt), mostly affecting "the upper extremity, and, as a rule, only one," and confined to one side when in the lower extremity. The greatly enlarged muscular fibres have, in certain cases, been found capable of doing much work for a short time, though soon tiring; while in other cases the actual strength of the muscle has been lessened rather than increased.

Atrophy of Muscle.—Atrophy of muscle may be either simple or degenerative, there being in all cases a diminution in the size of the muscular fibres, and corresponding lessening of the muscles themselves, except in the comparatively rare instances in which atrophy is masked by excessive fat development. This change may be consequent upon either disuse, nerve-lesion, injury of a bone or joint in close proximity to the muscle, disease of spinal or cerebral location—atrophy, however, rarely occurring in the latter, unless the pons be the seat of the affection—or some constitutional malady, attended with a depraved or poisoned state of the blood.

In simple atrophy there is found only a diminished size of the primitive fibre, no change occurring in the connective tissue except in very pronounced cases. Such is the form of atrophy usually declared to be met with as the result of muscular repose or disuse. It is questionable, however, whether simple disuse produces any real muscular atrophy. Certain it is, that when the cessation of voluntary movement does not depend upon some injury of joint, bone, or nerve, even though it be very prolonged, there is often no resulting diminution in the size of the muscular elements; and in the great majority of cases of disuse, the atrophy is without doubt reflex in its character. Simple atrophy is found also in a considerable proportion of cases of nerve injury; in a majority of those of fracture and dislocation of the vertebral column, in which death does not early occur; in vertebral caries; and in lesions confined to the brain. It is the form most usually met with in cases of infantile paralysis and of progressive muscular atrophy.

Much more interesting from a pathological point of view, and of much more importance, clinically considered, are the atrophies accompanied by degenerative changes. These may be either *granular*, *pigmentary*, *fatty*, or *waxy*.

*Granular Degeneration.*—In this form of degeneration, which is not infrequently associated with the fatty, the muscle-fibre is found to have lost its clearly defined striation, and the sheath to be occupied with a number, greater or less according to circumstances, of granules of varying size and of albuminoid character. By some regarded as simply a passive change, due to causes outside of the muscle, it has by others been considered as the result of inflammation; in fact, simply the cloudy swelling of the early stages of that process.

*Pigmentary Degeneration.*—Pigmentary degeneration, as its name would indicate, is characterized by the presence of dark pigment granules within the sarcolemma, such deposit in the muscles of the human subject, other than the cardiac, being always pathological, and often found in connection with the atrophies consequent upon cachectic conditions, upon much diminished food supply, and upon the marasmus of old age. It is as yet undetermined

whether the pigment is of hæmatic origin, or whether it results from changes in the coloring matter of the muscle.

*Fatty Degeneration.*—In the fatty degeneration proper, fat granules are found in varying amount in the sarcous elements, in the earlier stages only in the immediate vicinity of the nucleus, but at a later period substituting more or less completely the contractile substance, with corresponding destruction of the invaded part of the muscle. This change, usually slowly produced and of limited extent, may, on the other hand, be very rapidly developed, and may affect, more or less, all the muscles of the body, as notably in cases of phosphorus poisoning. Such fatty-degenerated muscle-fibre must generally, perhaps always, be absorbed, though possibly at times the absorption may be only of the fat granules. It is very probable, judging from the results of experimental investigations upon similar changes occurring in certain of the lower orders of animals, that the absorption of the substituted fat in chronic cases may occasionally be followed by muscular re-development. Besides this true degeneration, fat is found both within and without the sarcolemma as an infiltration or accumulation, either producing no effect upon the contractile substance, or destroying it simply by pressure. The deposit in the connective tissue between the fibrillæ, pathological in many cases, as, for example, after nerve lesions (when, according to Vulpian, true fatty degeneration never occurs), is very often met with as a physiological change, purely compensatory, filling up the spaces that are left by the fibres undergoing simple atrophy.

*Waxy Degeneration; Vitreous Degeneration.*—In this form, attention to which was first called by Zenker, the muscular elements are found to be converted into a peculiar, transparent, waxy or vitreous mass, exceedingly friable, readily breaking up into cuboidal blocks, while the muscular connective tissue at the same time undergoes proliferation. This is the form of degeneration so frequently met with in yellow fever and typhoid fever, and which occurs also in typhus, scarlet fever, and some other acute febrile affections. It has been observed also in cases of tetanus, and in the immediate vicinity of tumors, and has occasionally, though very rarely, been found after nerve lesions. Not all the muscular fibres usually are involved, some perfectly healthy being found in immediate relation with those more or less completely degenerated. As might naturally be expected, this condition is associated with weakness, more or less pain, and marked impairment of the functional integrity of the muscles, which, as we have already seen, are not infrequently ruptured in consequence of very slight violence.

Various theories have been proposed in explanation of these degenerative changes—that they are due to a peculiar infection; to high heat, which condition Claude Bernard has proved is a poison to the muscular tissue; and to muscle inflammation and its results: the latter is the view most generally adopted at present. Erb maintains that it is of the nature of a cadaveric change, requiring for its development an imbibition of serum and the absence of post-mortem rigidity, which latter condition is not developed in muscles thus affected. However produced, one thing is very certain, that it is a change that can end only in the destruction of the affected fibres. The vitreously degenerated sarcous elements must disappear, and new fibres take their place, in cases that recover. Whether these new fibres are developed wholly from the muscular cellules, or partly from cells of or outside of the perimysium, is a question as yet unsettled; or, as Strauss has expressed it, "The influence of the non-participation of the cellular elements of the perimysium, in muscular regeneration, is far from being as yet absolutely demonstrated." The same

question, as we have already seen, comes up in the consideration of the regeneration of muscular fibre after wounds and ruptures.

Under what circumstances are these several forms of degenerative atrophy likely to occur? When the muscular affection is consequent upon lesions of the anterior horns of the spinal cord (the "amyotrophies of spinal origin" of Charcot), there may be no degeneration whatsoever, simple atrophy alone existing; but in the great majority of cases the granulo-fatty change will sooner or later be detected, sometimes with associated pigmentary deposits, and the hyperplasia of chronic myositis will be found present in the connective-tissue framework of the muscle. If there be any acute inflammation of the cord, fatty degeneration rapidly follows. In a case reported by Little, of dislocation of the fifth from the sixth cervical vertebra, complete atrophy of the muscles of the forearm was present by the end of the second week. When it is nerve injury that has given rise to muscle-lesions, these latter are, as we have seen, according to Vulpian's investigations, always limited to the perimysium, and are hyperplastic and fatty. Others, however, claim that fatty degeneration of the muscular elements at times takes place. When the nerve damage is an irreparable one, the resulting atrophic changes are permanent and likely to go on from bad to worse; but when repair can and does take place, restoration of the muscles to their normal condition usually occurs, and that sometimes very rapidly. Markedly diminished blood-supply will cause the fatty change, as is physiologically observed in advanced life, and pathologically in cases of decided though incomplete arterial stenosis. Vitiation of the quality of the blood produces the same effect; sometimes very rapidly and generally, as in the acute grave pyrexias and after taking certain of the poisons, such as phosphorus and arsenic; sometimes more slowly and in more limited areas, as in the lead palsies.

The atrophy always to a greater or less extent associated with joint inflammations and fractures, which is simple and not degenerative, cannot, as long believed, be due to disuse, except, perhaps, in certain very chronic cases of arthritis, but is to be regarded as reflex. "It seems dependent upon disordered nervous influence, and often appears proportionate to the coincident pain, as if it were due to the disturbance of some nutritive nervous centre, irritated by the painful state of sensitive nerve fibres" (Paget). In case of fracture, Gosselin believes the wasting to result from "a change in the distribution of the nutritive material consequent upon the work of consolidation." The atrophy of stumps, which is also of the simple form and due to nerve-injury, has been found by Vulpian and others to be associated with wasting of that portion of the anterior columns from which arise the nerves distributed to the parts removed.

Three affections, in each of which muscular-atrophy is a most marked symptom, deserve special consideration, viz., progressive muscular atrophy, infantile paralysis, and pseudo-muscular hypertrophy.

*Progressive Muscular Atrophy.*—Progressive muscular atrophy, recognized by Bell but much more carefully studied by Cruveilhier, and subsequently by Duchenne, is characterized, as its name would indicate, by a progressive involvement of the various muscles of the body. Beginning usually in those of the hand (the external interosseous being ordinarily the muscle first affected), though sometimes commencing in those of the shoulder, and even, in rare cases, in those of the lower extremity, it gradually proceeds from muscle to muscle until the most marked atrophy characterizes the appearance of the upper part of the body; and the ultimate involvement of the respira-

tory muscles, or exhaustion, or associated gangrene from pressure, brings on a fatal termination, which is the almost certain result of the disease. Occasionally it has been found to be, not, as usually, chronic, but acute—rapid atrophy and early death occurring. Originally believed by the majority of pathologists to be primarily a myositis (and Friedreich has of late maintained the same theory of its nature), it is to-day generally recognized as originally a nerve lesion, the anterior portion of the spinal cord being the seat of the trouble. The muscular disturbance is one of inflammation, chronic in the great majority of cases, very rarely, as we have seen, acute; the myositis causing interstitial and fatty degeneration of the muscular elements, sometimes associated with proliferation of the connective tissue.

As this is a disease of middle life, so also is it one of the male sex, which is much more frequently affected than the female; and a strong hereditary influence has been observed in many cases. While perhaps not consequent upon them, its development is certainly favored by the existence of diseases attended with exhaustion, and dyscrasiæ, such as syphilis, lead-poisoning, etc. How much influence in its production is exerted by over-use, still remains a question. Cases have been observed in which the starting-point seemed to have been muscular injuries, crushings, etc. In the rare cases in which the lower extremities have been first involved, the disease has been observed usually in young subjects, and a pseudo-hypertrophic condition has been found associated with it.

The *diagnosis* of progressive muscular atrophy, at least when the disease is well developed, is easy. The peculiar wasting and the gradual progress, associated as it often is with fibrillary contractions, either occurring spontaneously or developed by slight blows, and the later, contracted condition of the muscles, with resulting deformities, such as the characteristic "griffed" hand, present an aggregation of symptoms which cannot be mistaken. At times, owing to an increase of the development of fat, atrophic deformity may be for a time masked. The *prognosis* is exceedingly grave, a fatal termination occurring in the great majority of instances.

*Infantile Paralysis.*—In this affection, belonging as its name indicates to the earlier years of life, there are observed much the same changes as in progressive muscular atrophy. It is a disease, however, not only of childhood, but one which is ordinarily acute, the paralytic condition of the muscles developing at first, frequently in the course of a few hours, or, at most, days, and the atrophy, which is usually simple, or, at times, associated with fibrous or fatty degeneration, quickly manifesting itself, having been observed as early as the fifteenth day, though commonly not for a month or two. The seat of the lesion has been very satisfactorily determined, and has been shown to be in the anterior horns of the spinal cord, there being a primary poliomyelitis with destruction of the cells. Here, as in progressive muscular atrophy, deformity, especially located in the lower extremities, is produced, and this deformity usually brings the case sooner or later under the care of the surgeon. The special management of these cases belongs properly to the department of orthopædic surgery, and will be considered in another part of the work. In very many cases, however, by early recognition of the disease and the institution of proper treatment (and of this the use of electricity is the most important element), the muscular wasting may be arrested, and partial, if not complete, restoration of the functional integrity secured.

*Pseudo-Hypertrophic Paralysis.*—This curious affection, which is also a disease of early life, in many respects strongly resembles progressive muscular atrophy and infantile paralysis. It differs from the former mainly in

the age at which it is manifested, and in the primary involvement of the lower, rather than of the upper extremity (although sometimes the latter is first attacked, and then usually there is simply progressive muscular atrophy without hypertrophy); and from both in the apparent, sometimes massive, increase of the size of the muscles. This increase, however, is only apparent, the muscular elements themselves being either unchanged or, as is sometimes the case, atrophied—such atrophy being associated with an excessive development of fat and proliferation of connective tissue. Not infrequently it happens that only a few of the muscles are hypertrophied, these being generally those of the calf and of the gluteal region, the other affected muscles, especially in the upper half of the body, being greatly wasted. Whether or not this affection, like progressive muscular atrophy and infantile paralysis, is of spinal origin, is still a question; the majority of observers have denied the existence of any associated or causative spinal lesion.

Ossification of Muscle.—As the result of chronic inflammation, true bone formation may take place in muscle, such development being either limited or general. In the former case, which is vastly the more common, the precedent connective-tissue inflammation is due, in the great majority of instances, to frequently repeated and long continued but comparatively slight traumatic irritations (as in the so-called "exercise bones," which, however, are generally located in the tendons rather than the muscles), but at times is of syphilitic origin. Not very infrequently circumscribed ossification will be found to have affected muscles in close proximity to exuberant callus after fracture. Once formed, the osseous masses or plates can usually be felt without difficulty, though their existence may be discovered only after death; and, according to their size, they will give rise to much, little, or no appreciable impairment of the full natural action of the muscle. Ordinarily they need not be interfered with, but at times they require removal.

*Myositis Ossificans.*—Of muscular inflammation, general in its character, and terminating in the conversion of the parts affected into bone, a few cases have been observed. Commencing in early life, even in infancy, affecting primarily the muscles of the neck and back, and then spreading to those of the extremities, and subsequently to those of the trunk, but sparing those of the tongue, larynx, and œsophagus, the heart and the diaphragm, and those of the genitals, and affecting the abdominal muscles only to a limited extent, this may be regarded as primarily a hyperplastic inflammation of the connective tissue, producing consequent atrophy of the muscular elements, and terminating in osseous transformation. As thus far observed, it does not seem to be hereditary. Its progress is slow and irregular, influenced to some extent by accidental and outside circumstances, but sooner or later the case terminates in death; either because of exhaustion, of involvement of the external muscles of respiration, or of local gangrene.

By most writers this affection has been declared to be independent of any nerve lesion, but Hayem has questioned if it has not close relation with an affection of the nervous system, since its characteristic lesions are inflammation, sclerosis, and atrophy, much resembling those of spinal origin. As far as has yet been determined, it is incurable by any method of treatment, though the affected individual may live for a number of years.

Rheumatic and Gonorrhœal Inflammation of Muscle.—So-called "muscular rheumatism," which in many cases doubtless is rheumatic only in name, is, as has already been stated, sometimes, perhaps generally, a true myositis, usually of short duration and terminating spontaneously in resolution, but at

times chronic in character, and giving rise to organic changes in both the sarcous elements and their investing connective tissue. In no case has suppuration been known to take place. It is most frequently located in the muscles of the neck (*rheumatic torticollis*), in those of the chest (*pleurodynia*), and especially in those of the back (*lumbago*). Once occurring, it is very liable to recur. Attributed oftentimes to the influence of drafts of air striking upon a surface over-heated or in a state of active perspiration, in many cases, perhaps in the majority, it is really due to twists, strains, or ruptures of the muscular or tendinous fibres or of their sheaths; in other words, is actually traumatic. Diagnosticated by the pain and inability to move, and the muscular contraction with sometimes resulting deformity, it is to be treated by rest, heat, stimulating applications, opium by the mouth or, still better, hypodermically, and especially by electricity, the effect of the application of which is often very rapidly beneficial.

As a complication of gonorrhea, so-called "gonorrheal rheumatism" sometimes occurs in the male, more rarely in the female. In this affection the muscles have in a few cases been evidently the seat of an inflammation differing from ordinary myositis only in its exciting cause, and in its constant association with arthritis, usually mono-articular.

Syphilitic Affections of Muscles.—Affections of the muscular system consequent upon syphilitic infection, may manifest themselves at an early or late stage of the disease. In the former they are such as arise from nervous disturbance (pain, weakness, unsteadiness of action); in the latter, from organic changes and deposits.

*Syphilitic Myalgia.*—In the secondary period of syphilis, myalgias are often met with, and, indeed, in mild form, at some time or other, are almost constant. They are much more common in women than in men (as are all the specific disturbances of nerve-origin), are worse at night or in the early morning than in the daytime, are aggravated by exercise or pressure, last a variable length of time, and always disappear, sometimes as suddenly as they came on. The pain is located in the belly of the muscle, and ordinarily in only a part of that; it may affect one or more muscles (those of the thighs and legs being the more usual seats), is often indefinite and wandering, and may be associated with, and—unless care be taken in the observance of its phenomena—may be easily mistaken for, pain arising from affections of the neighboring joints, bones, or tendons. The *treatment* must be both anti-syphilitic and anodyne, and much benefit will often follow local counter-irritation, and still more frequently the employment of hot applications, especially of the vapor bath. Muscular weakness is always present to a greater or less extent, and may be so prominent as to prevent the taking of any exercise, or even the getting out of bed. As the result of inaction, or as a reflex phenomenon, atrophy occurs, sometimes in high degree.

*Syphilitic Tremor, etc.*—As was originally pointed out by Fournier, there may occasionally at this period of syphilis be detected in certain of the muscles tremblings, fibrillary contractions, not due to any central nerve-lesion, but "simply a functional disturbance, essentially temporary, and necessarily benign." Arising suddenly, affecting primarily and chiefly the muscles of the upper extremity, and ordinarily only a part of these, this trembling may be both seen and felt, and can without difficulty be graphically traced. The duration of the affection varies from a few days to five or six months, and in the more protracted cases (lasting from "four to eight or ten weeks"), which are those usually met with, the tremblings are frequently intermittent.

*Syphilitic Contracture.*—As a consequence of a myositis of low grade, occurring both in the earlier and later periods of syphilis—even as early as the second month, according to Mauriac—muscular contracture at times takes place. Actual shortening may or may not exist, but whether it does or not, full extension cannot be made, the degree of limitation having been observed at times to exceed 90°. The biceps flexor cubiti is the muscle that is almost always affected, and there has been observed at the same time contraction of the triceps extensor, so that true muscular anchylosis has been caused. In the contracture occurring in the early period of syphilis, though there may be some little pain produced by pressure over the musculo-tendinous junction, the progressive flexion is the symptom that will at once attract attention and permit of a diagnosis being made. The muscle and all the structures entering into the formation of the elbow-joint are apparently perfectly healthy; "the patient presents himself with the forearm flexed upon the arm and immobilized in that position," and that is all. By the ordinary anti-syphilitic treatment this early rigidity may usually be made to disappear.

The contractures coming on later, and not due to gummata, are the result of diffuse myositis, there being produced the "simple fibrous inflammation" of Virchow in the midst of the interstitial tissue of the muscular bundles, a connective tissue forming "which hardens and destroys, after having caused their atrophy, the primitive muscular fibrillæ." The biceps is the usual seat of this form of contracture also, but by no means as exclusively as of that already noticed. In many of these late-appearing cases it is very probable that the causative lesion has been not a primary myositis, but a bursitis or an arthritis which has either disappeared or is lost sight of in the presence of the secondary muscle-inflammation.

*Gummata of Muscle.*—Gummy tumors are not infrequently met with in the muscles, especially in those of the upper extremity and the neck. Their histological character is the same as that of those located elsewhere, they being made up of young round cells with single nuclei that rapidly tend to undergo fatty degeneration. The perimysium is probably the original seat of the gummatous deposit, either no change or a fatty degeneration of the muscular elements being seen, according to the period of observation. Sometimes escaping notice, these gummata, which frequently attain quite considerable size, usually attract attention both on account of their volume and the functional disturbances to which they give rise, though their nature may be misunderstood, a gumma being sometimes mistaken for a sarcoma or fibroma, or, in the tongue particularly, for a carcinoma.

The *diagnosis* may, generally, be readily made by remembering that gummata are swellings of the muscles rather than tumors in them; by noting their firmness, the induration being most easily detected when the muscle is in a state of relaxation, though the natural hardness is greatest during contraction; and by observing their location in the long muscles near their points of insertion, their occurrence in syphilitic subjects, and the results of anti-syphilitic treatment. They usually belong to the accidents of the later periods of syphilis, but at times are met with during the secondary stage. Under proper treatment, their disappearance may generally be secured in the course of a few weeks, or at most months, and even when left to themselves they sometimes disappear. Usually, however, they after a time soften, break down, and by the establishment of sinuses discharge themselves, or, as is more common, again become harder and undergo calcareous or even osseous transformation. It is doubtful if they ever suppurate; indeed, Mauriac has declared that the nonformation of pus is one of their characteristics which is of great value in the establishment of a differential diagnosis.

Contracture of greater or less degree may be produced by the presence of gummata, and such contractures at times remain during the entire after-life of the individual affected, though the gummata themselves may have disappeared long before death. The functional integrity of the muscle is always more or less impaired when cartilaginous or, still more, osseous degeneration has taken place.

The *treatment* of gummy tumors is constitutional, consisting in the administration of the iodides, either with or without mercury. Local applications are of little or no benefit, and extirpation of the tumors, which has at times been practised (commonly, it is true, because of an error in diagnosis), is quite unjustifiable.

TUMORS OF MUSCLES.—Tumors may be located in muscles either by original development, or by extension from neighboring parts. They may be either benign or malignant in character, both sarcomatous and carcinomatous growths being embraced in the latter division.

*Non-Malignant Tumors.*—Primary *lipomata* and *enchondromata*, though found in muscles, are pathological rarities, much more so than might be supposed, taking into consideration the amount of connective tissue and supported fat that is found in the muscular structure.

*Vascular tumors* are much more common, both those due to dilatation and those arising from rupture of vessels. The former (*angeiomata* proper) are seldom primary, and almost never purely muscular, the skin and subcutaneous tissues, as well as the muscles, containing the growths at the same time, either by association or by extension. As shown by Broca, "these erectile tumors of muscle are always principally venous." *Hæmatomata* following muscle-ruptures are quite common, and when superficial may usually be readily detected by the fulness and softness of the existing swelling, and by the generally-associated discoloration of the skin. In the deeper muscles (and it is in these, especially in the rectus abdominis, that the extravasation-tumor more often occurs) the swelling may be overlooked or mistaken for that dependent upon the contraction of the torn fibres of the muscle. As we have already seen when treating of muscular ruptures, the very nature of the accident may be altogether misunderstood, and the case treated as one, for instance, of intestinal obstruction. In cases of doubt, exploration with a fine trocar or the needle of an aspirator will usually establish the diagnosis. Suppuration, though not very likely to occur, does at times take place, and may be the cause of death, as when an abscess in the rectus abdominis bursts into the peritoneal cavity.

Though usually not very large, the hæmatoma occasionally reaches an extraordinary size, as in Virchow's case where the tumor was over $3\frac{1}{4}$ inches long, $2\frac{3}{4}$ inches wide, and $2\frac{1}{4}$ inches thick, the torn muscle being the right iliacus internus and the patient a "bleeder;" and as in Richardson's case, in which rupture of the right rectus abdominis from muscular effort was followed by a hemorrhage from the torn internal epigastric artery to the amount of a half-pound clot, occupying a cavity made by the retraction of the torn muscular fibres to the extent of from "one and a half to two inches." Cure ordinarily takes place by absorption, but at times a firm, thick, cartilaginous sac-wall with contained shrivelled and broken-down corpuscles remains ever afterwards, causing more or less disturbance of the muscular movements.

The *treatment* appropriate for the rupture is that best fitted to produce removal of the extravasated blood, aided, if necessary, by aspiration. If the coagulum is too firm to be thus gotten rid of, after a reasonable length of time has been allowed for the occurrence of absorption, without this having taken place, it will be advisable to cut into the tumor and turn out the

contents, or, if necessary, cut away its investing sac. With antiseptic precautions the chances are that such radical treatment will be attended with but little danger.

*Malignant Tumors.*—The malignant tumors, *sarcomata* and *carcinomata*, are often found involving the muscles, the former both primarily and by extension, the latter probably always secondarily, though it is still held by some that true primary cancer of muscle may occur. That the connective-tissue type of malignant growths should spring up and develop in muscle is only what naturally might be expected. Occasional specimens of mixed fatty, vascular and sarcomatous tumors have been observed. But one form of treatment is to be thought of in these cases of malignant growth; thorough removal of the affected parts. Some have even gone so far, recognizing the ready secondary involvement of muscles in close proximity to cancers, as to insist not only upon the propriety but the necessity of the removal of such muscles, even though they may seem to the naked eye to be perfectly healthy. Particularly would they have this rule observed with reference to the pectoral muscle in carcinoma of the breast.

*Parasitic Tumors.*—Parasitic tumors are consequent upon the entrance into and development in the muscle of either the echinococcus, the cysticercus, or the trichina. The first of these (*echinococcus*) has been comparatively seldom observed, is ordinarily of slow growth, and causes usually but little disturbance and that simply by its size. At times a chronic myositis, occurring about the parasite, causes its inclusion in a thick-walled sac, and occasionally its presence lights up an acute inflammation which may result in the formation of abscess and in spontaneous discharge. The diagnosis of hydatid in muscle must generally be based upon the recognition of a slowly enlarging cyst with absence of all inflammation, and finally (and this will often be the only evidence of value), the discovery in the removed fluid of the "hooklets."

The *cysticerci* are much more frequently met with in the muscles, but their presence is quite unlikely to be recognized, since, unless possibly when in large numbers, they produce few or no symptoms, not even a characteristic muscular weakness, and the little swellings they may cause can rarely if ever be detected before death.

Of much greater importance are the effects of the entrance into and lodgment in the muscle of the *trichinæ.* Transported from the alimentary canal either along the blood-currents or by self-progression through the connective tissue, the embryo-parasites soon find their proper place of development in the muscular fibrillæ, where they excite an acute myositis, as evidenced by pain, cramps, indurations, tenderness on pressure, and marked impairment of function, and, microscopically, by destruction of the sarcous elements and thickening of the sarcolemma. Even before the entrance of the worms into the muscles, there is experienced a "muscular lameness," the cause of which is still uncertain. The severity of these earlier muscular symptoms is directly proportionate to the number of the trichinæ, as indeed are all the symptoms of the disease. After having attained their full maturity the parasites become encapsulated, and a state of chronic myositis succeeds to the acute, its duration and severity being exceedingly variable. Generally, calcareous deposits sooner or later take place in the capsule-walls, and then the little tumors become readily visible to the naked eye. The after-life of these encysted trichinæ may be short or long—sometimes even longer than that of the individual in whose tissues they are lodged.

## Injuries and Diseases of Tendons.

Ruptures of Tendons.—Much more frequently than similar injuries of muscles, ruptures of tendons may take place as the result of sudden violent efforts, the occurrence of such an accident being indicated by a snap, often both felt and heard, by pain, by immediate arrestation of muscular movement, and when the tendon is, as is generally the case, in the lower extremity, by falling of the body. Oftentimes there is a visible depression at the place of injury, and upon palpation a distinct sulcus of varying width can readily be detected, the examination when made early causing little or no pain. The entire tendon generally gives way, but partial rupture may take place.

In the majority of cases it is either the tendon of the rectus femoris below or above the patella, the tendo Achillis, or the tendon of the triceps extensor or that of the biceps flexor cubiti, that is broken, the relative frequency being in the order stated. As in the similar injury of a muscle, approximation of the separated ends of the tendon is to be favored as much as possible by position and appropriate bandaging, and rest must be maintained, best by immobilization of the limb. From six weeks to two months is usually required for the completion of the repair. The loss of muscular power generally resulting from the presence of a long connective-tissue band between the tendon ends (and it is in this way oftentimes that repair takes place), makes it probable that when there is wide gaping the wisest course is to suture the tendon at once, a procedure that, antiseptically carried out, seems to be attended with very little risk.

When there is rupture of the tendon of the *rectus femoris*, or of the *ligamentum patellæ* (and these should be considered with reference to this accident as one and the same tendon of insertion, with a contained sesamoid bone), it is almost always due to an unusual and involuntary muscular contraction, the fall being secondary, the consequence and not the cause of the injury. As in fracture of the patella, from which lesion alone a differential diagnosis is to be made, there is immediate inability to lift the extended leg, and more or less inflammation of the knee-joint is likely to be quickly developed.

In rupture of the *tendo Achillis*, it is generally impossible to either stand or walk, and the tendinous interspace can be shortened by forced extension, and lengthened by forced flexion of the foot upon the leg. When the long head of the *biceps flexor cubiti* has given way, the part of the muscle steadied by the short head will be seen upon voluntary contraction to be thrown prominently into relief, while the rest remains flaccid.

Wounds of Tendons.—These may be either punctured, subcutaneous, or open. The former are usually of little importance, either no symptoms being manifested, or slight ones only, spontaneously passing off in the course of a few hours or at most days. At times, however, as the result ordinarily not so much of the prick as of the entrance thereby of septic material, severe inflammation is developed, with consequent suppuration within the sheath and necrosis of the tendon, or with grave constitutional disturbance that may be the cause of a fatal result.

Complete *subcutaneous* wounds, typical examples of which are met with in operations of tenotomy, are attended with a distinct snap and decided separation of the ends of the tendon, with consequent depression at the seat of injury, always to be felt and usually to be seen. The attendant hemorrhage is slight, and the pain not severe. Plastic effusion takes place around and between the separated ends of tendon, a connective-tissue callus is developed, contrac

tion of this interposed band occurs, and in the course of a few weeks the reparative process is ended. The restoration of the tendon to its original functional integrity is more or less perfect according to the closeness of the primary approximation, the absence or presence of suppuration (which at times occurs), the degree of quietude maintained, and the healthy or unhealthy condition of the system at large. The *treatment* of these wounds is usually very simple, consisting in the enforcement of rest, with compression and immobilization of the limb. Whether or not the divided ends of the tendon should be brought as nearly as possible together, or should be kept separated, will depend upon whether the wound is one accidentally made in a healthy tendon, or intentionally in one which is contracted, in order that deformity may be corrected.

*Open wounds* are injuries of much more gravity, severe local and constitutional symptoms very often being developed. The retraction is greater and the hemorrhage more profuse. Inflammation is always excited, except in the rare case in which primary union of the divided overlying soft parts quickly converts the open into a subcutaneous wound. When it is a tendon of the hand or foot which has been divided, the inflammation is very likely to spread rapidly along the sheath, and may produce speedy death of the tendon itself. As the result of exposure, necrosis of a tendon at times takes place, attended with considerable suppuration, and not infrequently with grave pyæmic or septicæmic conditions.

The favorable or unfavorable issue of a case of open tendon-wound largely depends upon the treatment adopted, though affected of course by the existing constitutional state. Other things being equal, the danger is decidedly greater when the injury is of a tendon having a synovial sheath. Even a subcutaneous wound of such a tendon is likely to be followed by destructive inflammation, and hence tenotomy should in such cases be avoided. Apposition of the separated ends, if possible, is to be effected, or at least approximation as close as may be, and the wound of the overlying tissues should be closed if practicable, in order that primary union may perchance occur. Such a position of the parts is to be adopted as will best prevent movement of the damaged muscle, and this should be maintained by the use of fixed dressings, the plaster-of-Paris bandage being preferable to any other.

Of the propriety, not to say necessity, in many cases, of uniting the divided ends of a cut tendon by *sutures*, there cannot at the present day be much question, as far as recent wounds are concerned. Even if a considerable time has elapsed since the injury and cicatrization of the wound has taken place, if the functional impairment is great, the ends of the tendon should be sought for, and, when found and freshened, united by sutures, preferably of wire, since silk sets up too much irritation, and catgut melts down too soon. If the upper end of the tendon cannot be found, the lower end may be attached to a contiguous tendon, as has been several times done successfully, and if the lower end is fixed in the cicatrix, the upper may be also fastened into it, and voluntary movement of the supplied part thus regained, as occurred in Chassaignac's case more than a quarter of a century ago, and in B. Anger's much more recently. Tendon stitching has been successfully employed also in operations for the relief of talipes calcaneus, a portion of the elongated tendo Achillis being removed and its ends adjusted with sutures.

Displacements of Tendons.—As a result of sudden movements or extreme violence, a tendon may be forced out of its normal position, replacement occurring either spontaneously or by the aid of surgical interference. Thus in a certain proportion of cases of fracture of the lower end of the radius, the tendon of the extensor carpi ulnaris is believed by some to be thrown

out of its proper groove on the posterior surface of the head of the ulna; and the tendon of the long head of the biceps flexor cubiti has been frequently reported as displaced from the bicipital groove. But there is good reason for doubting the actual occurrence of either of these accidents.

There can, however, be no question that displacement of the peroneal tendons, especially that of the peroneus brevis from its bed behind the external malleolus, does take place, and that not so very seldom. Coming forward upon the malleolus, it can be readily felt, and slight manipulation will suffice to carry it back to its normal place. To retain it there, though, is a matter of much difficulty; of impossibility, indeed, in many if not in most cases. All that can be done is, after replacement, to apply a retentive bandage, preferably immovable or elastic, and keep the parts quiet for a number of weeks until reunion of the torn lateral ligaments or fascial investment shall have taken place, if this can be secured. Similar ease of restitution and difficulty of maintenance have been found to be the rule in the analogous displacement of the latissimus dorsi muscle from the inferior angle of the scapula.

INFLAMMATION OF THE SHEATHS OF TENDONS.—Inflammation of tendinous synovial sheaths (*tenosynovitis* or *thecitis*) is frequently met with, and may be either acute or chronic. Almost always, if not always, of traumatic origin, oftentimes the exciting cause is not a single severe bruise or wound, but long-continued slight irritations or tendinous movements, as in various sorts of manual occupations.

*Acute Tenosynovitis.*—In the acute form, not dependent upon an open wound, pain more or less severe is usually the first noticed symptom, such pain being limited to the region of the affected tendon, and aggravated upon movement. Swelling soon appears along the course of the tendon, which is most usually one of the radio-carpal extensors in the forearm, or one of the finger extensors in the neighborhood of the wrist, or one of the peroneals or flexors in close relation with the malleoli—much less frequently one of those crossing the anterior surface of the ankle. Occasionally the long head of the biceps flexor cubiti has been found to be the seat of the disease. Associated with the pain and swelling is the peculiar and characteristic crepitation, which may be both felt and heard, whence the name "crepitating tenosynovitis." Differing from the sharp grating sound of the crepitus of broken bones, and from the "compressed bladder, half-filled with air" crackling of emphysema (though Lobstein thought that it was really emphysematous and due to an accumulation of gas in the synovial sheaths), the sound has been likened to that produced by the rustling of silk. This crepitation, due to the rubbing together of the exudation-lined walls of the synovial sac, ordinarily continues in the milder cases not more than a couple of weeks, diminishing in proportion as the fibrinous exudation is absorbed. In the severer cases it is likely to disappear earlier, being stopped by the separation of the inflamed walls by serous or purulent accumulations.

These more violent inflammations are ordinarily consequent upon severe contusions or open wounds of the sheath, as in amputations of the fingers, through the hand, or through the tarsus, less frequently in amputations of the toes. The symptoms are all strongly marked, the pain especially being very severe. Suppuration early takes place, either limited—there being sometimes two or more separated foci—or diffused, rapidly extending up the sheath and involving the connective-tissue planes of the forearm or leg. Very often there is lighted up destructive inflammation of the contiguous bones and joints, and, as shown by Bryant's case, even dangerous hemorrhage may be kept up by the presence of the necrosed tendon. The constitutional symptoms are pro-

portionately grave. If not properly and promptly treated, death of the tendon soon takes place, and not infrequently pyæmia is developed. At the best the recovery will be but imperfect, with more or less tendinous adhesion and consequent restriction of movement, and often anchylosis of the affected joints; marked deformity is likely to result in the severe cases, from loss of substance and cicatricial attachments.

*Treatment.*—The inflammation in the mild cases may generally be controlled by rest (best secured by immobilization of the part) and by pressure. Slightly stimulant applications are believed to be of service, but the tincture of iodine, which is ordinarily used, either does no good or positive harm, in that valuable time is wasted in its application. In its very commencement, the severer form of tenosynovitis may sometimes be arrested by the application of heat, either by fomentations or poultices, or by local depletion, much more often by compression, particularly when made with the elastic bandage, applied not only to the affected part but over a large extent of the limb. Thus used, the rubber bandage is for every reason much to be preferred to digital compression or ligation of the main artery, both of which have been resorted to. Failing by these measures to arrest the disease, as shown by the increase of pain and tension, the affected tendinous sheath should be freely opened; much more imperative is the use of the knife if suppuration has actually taken place, as indicated by aggravation of the local symptoms with an added throbbing and the occurrence of rigors. If one incision does not suffice to arrest the disease, others must be made, and the course of the inflammation must be followed up and suppuration "headed off" if possible. The affected part should be elevated, and hot applications should be continuously employed. If the tendon dies, it should be speedily removed, especially if there is much bleeding from the wound.

The constitutional treatment must of course be that which will relieve pain and sustain strength. Opium is always indicated, and alcohol is usually demanded sooner or later in other than the mildest cases. Pyæmia, if it develops, must be treated in the usual way. Destructive inflammation of the bones and joints may render amputation necessary.

*Chronic Tenosynovitis.*—The chronic variety of tenosynovitis, which affects much the same tendons as the acute, may be either consecutive to the former, or may be chronic from the start. As its name indicates, it is of long duration, and its symptoms are not severe. But little pain is experienced except when the part is struck, and when spontaneous pain is present it has been observed to be of intermittent character, and, in the majority of cases, in tenosynovitis of the upper extremities. Rarely getting well when left to itself, this form of the disease is very apt to give rise to, or at least to be associated with, inflammation of neighboring bones and joints. There seems to be good reason for believing that in some cases of fungous arthritis, the disease has originated in the synovial sheaths of tendons crossing the joint.

Swelling is the especial symptom of this chronic tenosynovitis, following at first the course of the tendon, of elongated shape, changing its position slightly when the tendon is acted upon by muscular contraction, movable from side to side, and, after a time, involving the neighboring parts, which become more or less thoroughly matted together. The synovial sac is filled with fungous, highly vascular granulations of varying firmness, whence the name fungous tenosynovitis. Sooner or later, spontaneously or as the result of an opening of the sheath, mushroom-like masses are likely to show themselves externally, when the case may be easily mistaken for one of malignant disease. It occurs most often in the earlier years of mature life, and in men

rather than in women—as might naturally be expected, since it is of traumatic origin.

*Treatment*, other than operative, is seldom of any benefit. Rest, massage, blisters, sulphur-baths, and pressure, are occasionally of advantage, and irritant injections at times cause a disappearance in part, or wholly, of the granulations, though usually all of these methods of treatment result only in failure. If the disease has not progressed so far as to necessitate amputation, or if the tendon itself is not so buried and fused in the fungous masses that it cannot be dissected out, these masses must be thoroughly cut or scraped away; with antiseptic precautions, such operations are attended with but little risk to either life or limb. Partial removal of the diseased tissue is sure to be followed by early re-development of the trouble; consequently, if amputation is not required, and if complete extirpation cannot be effected, a simple compressing bandage should be worn, and further interference abstained from.

Paronychia and Felon.—As the result of injury, often of slight degree, such as a pinch, a scratch, or a needle prick, affecting a finger, and especially the palmar surface of a distal division, inflammation is developed, located outside the investing deep fascia, in the tendinous sheath, or in the periosteum and phalanx—or, as is more usually the case, wherever originating, involving all the parts through extension by contiguity, as also by direct continuity, since the layers of tissue from bone to skin are here united by fibrous threads passing through the interstices of the cribrillated periosteum, up and into the under surface of the derm. This anatomical constitution, which is peculiar to the region under consideration, however advantageous in limiting the movement of the skin and thus insuring accuracy of touch, is very favorable to the rapid extension of inflammation, and is unquestionably the cause of the frequent severe results that follow the slight injuries already referred to. Wherever situated, and usually it is primarily in the superficial fascia, the pain attending these finger inflammations is very severe, the tension decided, and the swelling great. Suppuration early takes place, and the pus may be located superficially, as it is in the milder cases, or about and beneath the sheath of the tendon. When the latter is involved, the tenosynovitis rapidly extends upwards, and if not arrested by treatment passes along the entire length of the sheath, to near the metacarpo-phalangeal articulation in the index, middle, and ring fingers, into the palmar subfascial bursa when the little finger is the seat of the disease, and above the wrist when the thumb is the part affected. Such extension is indicated by the degree and location of the pain, by swelling over the course of the tendon, by inflammatory changes in the over-lying skin, and by constitutional disturbances of high grade. Great increase in the severity of the symptoms, with throbbing, mark the formation of pus.

Unless promptly relieved, and not always even then, necrosis of the tendon is very apt to follow, and if the diseased part is saved at all, it is so in only a very damaged condition. Periostitis and osteitis occur in a large proportion of cases, with frequent destruction of the phalanx, even when proper treatment is early instituted and thoroughly carried out. Oftentimes, in consequence, we must assume, of some outside influence, atmospheric or otherwise, these violent and destructive finger inflammations occur epidemically.

In the very commencement of the affection, the continued application of hot water, painting with the tincture of iodine, the use of a blister, or compression, best made by the elastic bandage, may arrest the inflammation. If such measures fail, as they are very apt to do, a full, free, deep incision must be made—such an incision not only relieving tension and permitting the escape of pus, if formed, but being of service also by the local depletion pro-

duced. If necessary for the evacuation of pus, the sheath of the tendon must be opened higher up, and free drainage must be secured. When there is resulting necrosis of the phalanx, and this will occur in a considerable proportion of cases in spite of all that can be done, ample time should be given for the spontaneous separation of the sequestrum, which can then be easily removed. Very often the epiphysis will be found healthy, so that the phalangeal articulation need not be opened. Simple extraction of the dead bone is much to be preferred to amputation, as by the filling in and contraction of the soft parts, an useful substitute for the original finger-end will remain.

Palmar Abscess.—As the result usually of the extension of the previously described tenosynovitis of the digital flexors, but sometimes as the consequence of long-continued irritation of a limited portion of the skin of the palm of the hand, with the formation of small callosities such as are frequent with various sorts of artisans, there is developed an acute inflammation of the great bursal pouch under cover of the palmar fascia. When the primary inflammation of the tendinous synovial sac is located on the index, middle, or ring finger, it is usually arrested spontaneously for a time at the metacarpo-phalangeal articulation, in consequence of the termination of the sac at that level. After a little delay, however, the barrier intervening between the tendinous sheath and the great pouch above, if they come in close contact with each other, is broken down; or, if they are more widely separated, as they often are, the inflammation is propagated along the interposed connective tissue, so that, whatever the anatomical arrangement, before very long the palmar sac is involved. If the little finger is the seat of the original trouble, the morbid action is usually led directly up to the palm of the hand, as the flexor-sheath of that finger ordinarily communicates with the subfascial pouch. Since the flexor-sheath of the thumb passes up separately on the palmar surface of the forearm, where it either opens into the continuation of the palmar sac above the wrist, or terminates in close relation with it, separated merely by a thin wall which may readily be broken through, it is only by downward progress, under and below the annular ligament, that central palmar inflammation and resulting abscess can arise from lesion originally confined to the thumb. Cases, however, may at times be met with in which the course of the disease proves that the usual anatomical arrangement does not exist; and this is not so much to be wondered at since, as has been said, "bursal sheaths are parts of great variability and inconstancy, and they early become changed in pathological conditions."

*Symptoms.*—Wherever originating, and however propagated to the subfascial space, acute palmar bursitis is indicated by great pain, by marked swelling, the natural concavity of the palm being changed into a convexity, by an œdematous and discolored condition of the skin, associated not infrequently with a superficial sub-epidermal suppuration, by high fever and decided general prostration. Suppuration quickly occurs, the pus-formation causing generally the usual and characteristic rigors. In the advanced stages of palmar abscess an error in *diagnosis* can hardly be made, but at an early period the nature of the disease may, and often does, escape recognition, the inflammation being believed to be but superficially located.

The *prognosis*, though much affected by treatment, is always grave, for seldom is the inflammation recovered from, be it never so slight or never so well treated, without some impairment of the functional integrity of the parts. When neglected or improperly treated, the danger both to the part and to life itself is very great, the patient, if recovering at all, doing so only after the lapse of much time, and then with a badly damaged hand, permanent flexion of the fingers in greater or less degree being ordinarily met with. Not

seldom does it happen that the inflammation, spreading from the palmar bursæ to the carpal and carpo-metacarpal articulations, completely destroys these, and at the same time produces necrosis of the bones entering into their formation, so that not infrequently amputation through the forearm is ultimately rendered necessary. Extension of the inflammation along the muscular planes of the forearm to the elbow, and thence along those of the arm even to the shoulder, frequently takes place, terminating favorably only after a protracted siege, and oftentimes causing death of the part if not of the patient. Occasionally, and not so very seldom either, as a result of suppuration in the palm or in the forearm, opening of a palmar arch or of one or more of the main vessels of the forearm occurs, the resulting hemorrhage necessitating an extensive dissection in order that its source may be ascertained, or, as sometimes happens, amputation of the extremity. Acute gangrene, quickly proving fatal, has been seen in connection with palmar abscess, and septicæmia is frequently observed.

*Treatment.*—The treatment to be adopted is as clearly defined as is the affection itself. The essential point is the early opening of the abscess and the securing of thorough drainage, due care, of course, being taken to avoid wounding important bloodvessels and nerves. If the first incision fails to put a stop to the extension of the disease, and burrowing of matter continues, subsequent openings must be made, in the palm of the hand, above the annular ligament, or anywhere in the forearm where pus is evidently accumulated. Anodynes, stimulants, and a general supporting treatment will be required, according to the circumstances of the individual case. Very favorable reports have of late years been furnished by numerous surgeons of the value of the antiseptic method in the treatment of these palmar abscesses, as respects both their evacuation and the prevention of troublesome and dangerous sequelæ.

Ganglion.—Serous cysts or, as they are usually called, *ganglia*, are often met with in connection with tendons, especially the extensors of the fingers (those of the extensor communis and extensor indicis particularly) and those of the toes; and by their presence they give rise to deformity, pain, and weakness. The ganglia which are so frequently seen upon the back of the wrist or hand, while generally but pouchings of the sheaths of the tendons, may be due to protrusions of the synovial membrane of the radio-carpal or carpal articulations, and much more rarely to serous distension of original or secondary mucous bursæ. The tendo-vaginal herniæ are most likely to appear just below or above the constricting posterior annular ligament, but the protrusions may be through normal or abnormal openings at other points. Frequently they appear suddenly, in consequence of exertion with associated twisting of the hand, but at times they are developed very slowly, by simple enlargement of the natural dilatations of the "end openings" in immediate relation with the annular ligament. The arthritic ganglia may be rapidly produced as the result of strain and twist, or slowly by enlargement of the "synoviparous crypts" of Gosselin. In the former case it is easy to determine the connection with the main synovial sac, since pressure suffices to press out the fluid, which more or less quickly returns according as the orifice of communication is large or small.

The *diagnosis* of ganglion is readily made; the history of its appearance, its location, its cystic contents, and the absence of inflammation in the overlying skin, at once indicate its nature.

Ganglia may be *treated* by rupture, by puncture, by subcutaneous section, by open division, or by partial or complete removal. Local applications and pressure at times cause a disappearance of the swelling, but thus effected the

removal is seldom a permanent one. In tense, thin- or moderately thick-walled cysts, pressure with the thumbs will suffice to burst them, rapid absorption of the effused contents will follow, and by the after-application of pressure a cure may be effected, though recurrence is likely to take place. In the case of firmer ganglia, forcible rupture, as, for instance, by striking them with a heavy book or weight, is not to be advised, on account of the likelihood of exciting severe inflammation. Subcutaneous section and laceration of the sac with a knife or spear-pointed needle is much to be preferred. The more radical operations of excision or open division have until recently been but little favored, on account of the great danger of exciting acute tenosynovitis, but now it is claimed that by the observance of strict antiseptic precautions all such risk may be avoided, and that in free incision with "thorough drainage and the promotion of the development of a granulation tissue" we have the best and safest method of permanently curing all forms of ganglia.

Tumors of Tendons.—These, like tumors of muscles, though occasionally originating from the tendon itself or its investing sheath, in the great majority of cases come from without, and by extension include or invade the tendon secondarily. They may be either cystic or solid, benign or malignant; due to some unknown cause, or directly consequent upon a constitutional affection, most generally syphilis. Ordinarily the tendon-involvement neither adds to the difficulty of diagnosis nor to the gravity of the case, except as it increases functional impairment, for the relief of which operative interference may be rendered necessary. *Cystic* tumors have already been considered. *Syphilitic* affections present much the same phenomena as when located in the bellies of the muscles, and are to be treated in a similar manner. At times a small and slowly-developing *fibroma* is found upon a tendon or its sheath, for instance, a finger-flexor, which by its presence may so interfere with movement as to make it advisable to remove the part or dissect off the growth. As a result of the latter procedure, tenosynovitis not seldom occurs; and though the likelihood of this happening may be materially lessened by the employment of the antiseptic method, still the danger is sufficiently great to compel a postponement of the operation until it is imperatively demanded.

Ossification of Tendons.—Bone-deposit of limited extent is frequently found in tendons, the ossification usually affecting the insertion-end. Met with as a consequence of frequently repeated slight blows or pressure (as in the so-called "exercise bones"), it may be due to nutritive change resulting from general disease, as in the subjects of rheumatoid arthritis, or may be consequent upon contiguous joint- or bone-injury, as in cases of old unreduced dislocations, or of fractures in which union has slowly taken place, and has been associated with the production of a large amount of callus. The diagnosis of bone-transformation is usually easy when the tendon is so superficial as to be readily felt. For the relief of the disability, if such there be, arising from the presence of these bony masses, nothing can be done except by operative interference, and this is but very rarely required or advisable.

## Injuries and Diseases of Fasciæ.

Investing and compressing the great muscular masses of the body, separating them from the superficial structures, and isolating them one from another, are found fascial sheets and aponeuroses, which have a positive surgical as

well as anatomical interest. Very scantily supplied with bloodvessels, and nourished largely by imbibition, they are in themselves but little prone to inflammation (which, however, does at times occur, producing effects to be presently considered), but are, when inter-muscular, easily affected by contiguous disease, which, cutting off the blood supply, causes necrosis, resulting in the separation of extensive sloughs.

The denser and more external layers of fascia, by hindering the distension of inflamed structures, greatly aggravate the attendant pain, and when suppuration has occurred, may very decidedly increase the difficulty of spontaneous evacuation of the pus, and the dangers consequent upon its presence, favoring, or actually compelling, burrowing of matter among the neighboring tissues, or its diversion towards more important parts. Thus, a sub-aponeurotic inflammation of the *head* will, if left to itself, spread widely under cover of the fascia, and cause much and dangerous destruction of tissue. Because of the overlying fascia, the swelling of a *parotid* inflammation may produce even fatal compression of the great vessels of this region, and the resulting pus may be compelled to find an outlet through the ear or the mouth, or to infiltrate the neck. Again, pus in the *episternal* pocket much more readily makes its way inwards and downwards to the anterior mediastinal space than through the external sheet of the deep fascia to the surface. As we have already seen, deep-seated inflammations of the *forearm* rapidly extend along the intermuscular septa towards and beyond the elbow, and extensive suppuration and sloughing are likely to occur; and a similar course is often taken by sub-aponeurotic phlegmons of the *leg*. At times pus is thus directed in a favorable rather than an unfavorable way, as in *caries of the dorso-lumbar vertebræ*, when by the firm sheath of the psoas it is led downwards towards the groin, or by the lumbar fascia outwards and backwards to the flank.

Accurate knowledge, therefore, of the position and attachments of fasciæ will enable the surgeon to foreknow the probable course of an inflammation, and will lead to an early opening of the resulting abscess, in order that the destruction of tissue may, as far as possible, be limited, and that local and constitutional dangers may be averted.

Repair of Fascial Wounds.—Because of the small number of nutrient vessels distributed to fasciæ, as already mentioned, primary union of their wounds cannot be effected—a fact to be borne in mind when one of the dense external aponeuroses has been incised or lacerated.

Contractures of Fasciæ.—As the result of chronic inflammation of low grade, resulting either from diathetic conditions, or from repeated though not severe injuries, shortening of a fascia at times takes place, with consequent deformity, more or less marked according to circumstances. Such contractures, as also the similar fascial conditions resulting from diseases of contained or covered structures (bones, ligaments or muscles), become important in direct proportion to their extent and the functional value of the parts affected. When the external portion of the *fascia lata* is thus diseased, progressive shortening may go on until the leg is strongly and permanently flexed upon the thigh; in which case nothing but an extensive division of the tense band will suffice for the removal of the deformity; and even then the relief may be but temporary, recontraction often taking place, notwithstanding the faithful use of mechanical appliances.

*Dupuytren's Finger Contraction.*—The most important, because the most frequent, of these fascial contractures is, undoubtedly, that of the palmar fascia, producing the so-called "Dupuytren's finger contraction." This

malady, which has long occupied the attention of surgeons, has very rarely been noticed in young subjects, is seldom seen in women, and, though a different opinion has been held by many, is more frequently met with in individuals of the middle and higher classes than among hand-laborers. Usually regarded as of traumatic origin, and as consequent upon frequently repeated slight irritations, as, for instance, the pressure of a tool handle, such a causation may well be questioned if it is most often a disease of those whose hands are not subjected to habitual pressure; and its frequent association with chronic dry arthritis makes it possible, not to say probable, that it is but an expression of a rheumatic or gouty diathesis. Ordinarily it affects but a single finger—either the ring or little finger—and never the thumb, for the simple reason, of course, that that digit is not connected with the true palmar fascia. Slowly developing, there is a steadily progressive drawing down of the finger towards the palm, the first phalanx only, as a rule, being flexed, though at times the second is so too. In the distal part of the palm, besides a more or less wide-spread thickening of the skin, there is to be seen and felt a well-defined, hard cord, thrown out in strong relief, following the course of the flexor tendon, most pronounced over the line of the metacarpo-phalangeal junction, and extending into the side rather than the anterior surface of the finger. Adhesions of greater or less extent will commonly be formed, sooner or later, between the fascia and skin.

That the abnormal flexion of the finger is not due to muscular contraction, is shown by the non-involvement of all its divisions, but only of the first or, at most, of the first and second; and also by the fact that no relaxation takes place under full anæsthesia. That it is the overlying fascia and not the tendon that is contracted, is proved by the healthy state of the latter found upon dissection, by the free and full movements of the finger that can be effected as soon as the tense fascial band is divided, and by the fact that the greatest elevation of the indurated cord is evidently over the metacarpo-phalangeal articulation, just where the tendon is most firmly fastened down. Repeated careful examinations have demonstrated that it is the digital prolongations of the palmar fascia that are primarily affected, the disease in time progressing up along the fascia to a variable distance, and occasionally, as shown by Adams, downwards along the lateral insertions to the second phalanx, in which case this part of the finger becomes contracted along with the first.

If left to themselves, these "finger-contractions" go on from bad to worse, and can only terminate in marked deformity and impairment of the usefulness of the hand. Internal medication, local applications, and mechanical appliances are of little or no value. Division of the band must be effected if relief is to be afforded; and this division may be either by open wound or subcutaneous, at one point or at many. If by *open wound*, the incision may be transverse and through the entire thickness of the skin and fascia—the method of Dupuytren—or longitudinal through the skin and transverse through the fascia, as practised by Goyrand; or there may be a V-shaped incision of the skin, with absolute removal of the contracted fascia, as in the more modern operation of Busch, the base of the flap corresponding to the line of the great transverse crease of the hand, and the apex extending to the highest point of the contraction. This flap may be left entirely to itself, or, after it has fully retracted, its edges may be stitched to the adjacent skin. No stretching out of the finger is to be attempted, either mechanically or by passive movement, until granulation is well established, and the operation and after-treatment should be conducted antiseptically. Though very favorable reports have been given of the results of "Busch's method," yet, in common with all the other operations by open wound, it must have in it an

element of danger, and there must be some probability of cicatricial reproduction of the flexion.

The idea of *subcutaneous section* of the contracted bands goes back certainly as far as the time of Sir Astley Cooper, and many surgeons have put it in practice with more or less satisfactory results. Quite recently Mr. Wm. Adams has very strongly presented the merits of this method of procedure, and has shown that, in his hands at least, it is at once easy, safe, and successful. He directs that a very small, straight-edged knife, smaller than the ordinary tenotome, shall be introduced just above and below where the skin is firmly adherent to the band, and the contracted tissue divided from above downwards; and if, as is often the case, these sections are insufficient to completely free the finger, other similar divisions are to be made wherever required—as many as, and no more than, will suffice to permit of full and perfect extension of the finger. Absolute rest of the hand and extended fingers is to be secured by the application of a light metallic splint, and the dressing is not to be disturbed until the fourth day. The splint is to be kept on night and day for two or three weeks, and afterwards at night only for three or four weeks longer, movement of the fingers being permitted during the day. Cases thus treated have so completely recovered that but slight traces have remained of either disease or operation, and the functional use of the hand and fingers has become and remained practically perfect.

# INJURIES AND SURGICAL DISEASES OF THE LYMPHATICS.

BY

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## Wounds of Lymphatics and Lymphatic Glands.

The enormous number of lymphatics which are distributed to every part of the body, in far greater number than the bloodvessels, renders it evident that in every wound or contusion in which bloodvessels are involved, lymphatics are involved also. The result is an outpouring of blood and lymph, and the outpoured lymph becomes ultimately developed into the bond of union whereby reparation of the injured tissue chiefly comes about. We notice that at first the flow from the wound is of both blood and lymph, and after a while a flow of clear lymph, which becomes organized. It does sometimes happen, even when there is no pathological change in the lymphatics, that a persistent flow of lymph may follow an injury, constituting what is termed lymphorrhœa or lymphorrhagia; and this traumatic form generally follows wounds of the thoracic duct, larger lymphatic vessels, or glands. In all wounds which involve large muscular surfaces, a considerable lymph flow occurs, owing to the rich network of vessels, by which, as demonstrated by Ludwig, the muscles are invested.

Wounds of the Thoracic Duct.—Cases of wounds of the thoracic duct have been placed on record, and it is possible that they may be of more frequent occurrence than is supposed, even if we set aside the fact of direct wound such as inflicted by a gunshot or puncture; rupture of the duct may result from a fall or twist, or from a growth, which may obliterate its lumen. From the cases placed on record, it would not seem that the lymph extravasation is necessarily at once, or, indeed, certainly fatal; and experiments and post-mortem records show us that, after obliteration of the duct, the circulation of the lymph has been restored by the collateral lymphatics and right lymphatic trunk.

Wounds of Large Lymphatic Trunks.—The chief interest attached to these is the resulting lymphorrhœa, and the oft-quoted case recorded by Hewson sufficiently illustrates the condition. This was the case of "a butcher, who, by letting his knife fall upon his shin, cut some of the large lymphatic vessels which pass over the tibia; from this wound there flowed a considerable quantity of clear lymph, which, being confined by the dressings, jellied, and then appeared at first sight like a whitish fungus, but being loose could

be removed by a spatula." This may be regarded as the typical condition resulting from a wound of a large superficial lymph trunk. Lymphorrhagia may follow wounds of the glands, or may be the result of a surgical operation, such as opening a bubo. The lymphorrhœa following dilatation of the lymphatics will be referred to hereafter.

*Treatment.*—This consists of pressure applied to the peripheral portion of the divided vessels, by the application of a suitable compress, such as a pad of lint soaked in a lotion of carbolic acid (1 in 40) and retained by a bandage. Any mismanagement may readily lead to the formation of a fistula, or to a troublesome lymphorrhœa.

## Lymphangeitis.

(Synonyms: *Lymphangioitis; Angeioleucitis.*)

We may conveniently consider the subject of lymphangeitis under two heads: simple and septic. Simple lymphangeitis (which we may regard as *reticular* and *tubular*) is most frequently of traumatic origin, although the idiopathic form occurs occasionally. The traumatic form is of the reticular variety, and although usually developed in the immediate vicinity of an injury, may show itself at some distance from such a lesion.

Reticular Lymphangeitis.—This form has a greater tendency to affect the external than the internal parts of the vessels, and can be most conveniently instanced in such cases as simple paronychia, erythema, or erythema nodosum, this latter being a reticular lymphangeitis with an added lymphatic œdema. Curnow calls attention to this connection between erythema nodosum and lymphangeitis, and instances a case in which there was such extensive effusion into the knee-joint that the case was supposed to be one of articular rheumatism. With regard to the form seen in paronychia, which may or may not be due to the introduction of a septic agent, and is frequently met with in anæmic seamstresses, the locality is almost invariably a terminal phalanx. It presents the usual characteristics of pain, heat, redness, and swelling—possibly, but not always, running on to suppuration, and that suppuration being subcuticular—red lines perhaps indicating the invasion of the superficial ducts, and neighboring glands swelling and becoming painful. The duration is usually very short, and in the earlier stages disinfection of the spot, or, if necessary, incision, with ordinary therapeutical agents and fresh air, soon effects a cure.

A variety, called the "wandering" by Curnow, is occasionally met with, unassociated with any breach of the skin, and due to frequent contact with septic tissues. Usually commencing on the dorsum of the hand, it "extends upwards by the successive appearance of multiple patches, occasionally but not always connected with wavy lines. Each patch lasts but a few days, and is quickly followed by another. They are extremely painful, and around them is a slight œdema. The corresponding glands are always enlarged and painful, even when there is no secondary implication of the main lymphatic trunk." I have had occasion to observe this condition since the appearance of the lectures in which the above quotation occurs.[1]

The superficial inflammation of lymphatics occurring in patches, would seem to correspond with the locality of adjacent anastomoses. This, from the fact of the patches being often unmarked by the wavy lines, may cause the nature of the condition to be overlooked. The deep form of reticular

[1] Lancet, April, 1879. Gulstonian Lectures.

lymphangeitis is a matter of which we know but little; it no doubt often occurs in association with diffuse cellulitis.

TUBULAR LYMPHANGEITIS.—Inflammation of the lymphatic ducts is characterized by wavy or, perhaps, straight red lines, hard and gritty to the feel, passing from the seat of injury, abrasion, or puncture, to the nearest lymphatic gland, which is swollen and tender; œdema of the tissues occurs, the course of these tracks is acutely painful, and there is considerable fever and high temperature.[1] The statement that the lymphangeitis is limited by the nearest lymphatic gland is certainly erroneous, and many opposing facts have been observed. Curnow (Gulstonian Lectures) quotes a case under his own observation in which septic material was absorbed by a wound, and the supracondyloid gland became inflamed, and subsequently the axillary glands; and he considers that this condition depends greatly on the nature and intensity of action of the exciting cause.

Various pathological changes take place in the lymph, lymphatics, and surrounding cellular tissue. The *lymph*, instead of being transparent, becomes opaque and full of cells; coagula, or thrombi, perhaps form; and the vessel becomes occluded. These thrombi are pinkish in color, and not as firm as venous thrombi. They generally form in the immediate neighborhood of the valves. Adherent to the wall of the vessel, they block or may obliterate its lumen, when a collateral circulation is set up. They may break down and become puriform. Dilatation occurs in the *lymphatics* themselves. They become thickened, the endothelium disappears, and the internal coat becomes opaque and uneven. The *cellular tissue* becomes œdematous (lymphatic œdema), owing to the exudation from the vessels, which may either resolve, become sclerosed, or suppurate. Bradley mentions that the chief danger in tubular lymphangeitis lies in the connective-tissue changes, and instances a case under his own care,[2] of cellulitis accompanying lymphangeitis of the neck, where a brawny œdematous collar encircled the part. The constitutional symptoms and urgent dyspnœa suggested tracheotomy. The tissues were, however, incised in the mesian line, and a director passed freely into the cellular tissue on either side, with the good result of a subsequent copious flow of pus, and ultimate recovery. Cellulitis may occur, dependent on lymphangeitis; and not infrequently arthritis, running on to suppuration. This latter complication has been particularly studied by Verneuil;[3] and a very similar case to that recorded by Bradley[4] was under my own observation, in which acute arthritis of the knee-joint followed an injury to the foot. The joint was opened antiseptically, a large amount of pus was evacuated, and the patient, a child, did perfectly well, regaining complete movement of the articulation.

Lymphangeitis may however succeed arthritis, more especially in the case of the knee-joint, and must be regarded as of extreme moment when suppuration supervenes.

The fact of suppuration does not necessarily imply a systemic sepsis, unless the pus contains germs, micrococci, or bacteria; and here indeed is the true difference between simple and septic lymphangeitis, and between non-infective and erysipelatous inflammation.

*Diagnosis.*—Ordinarily, simple lymphangeitis is readily diagnosed, phlebitis and erysipelas being the diseases most closely associated with it in appearance. We always have, in lymphangeitis, a temperature far higher than that in

[1] In certain cases of septic lymphangeitis, no glandular enlargement or pain occurs, while at the same time destructive suppuration is developed in the synovial sacs in the fingers and palm, which we must certainly regard as lymphatic réseaux.

[2] Bradley, Injuries and Diseases of the Lymphatic System, p. 64. London, 1879.

[3] Revue Mensuelle de Médecine et de Chirurgie, t. ii. pp. 816–821. Paris, 1878.

[4] Op. cit.

phlebitis; in erysipelas the redness is general, and there is absence of contagium.

The *prognosis* is usually favorable, with the exception of the occurrence of suppuration in the arthritic condition, which is a very serious complication in the septic form of the disease.

*Treatment.*—This must be both local and general: local so far as to reduce pain in the acute stage by the use of fomentations of poppy heads, and the application of belladonna and glycerine in equal parts, painted all over the suffering tissues.[1] If these are highly swollen and œdematous, perhaps bandaging with fine elastic webbing may be of service, and Bradley speaks highly of "massage;" but personally I have had no experience of this method.[2]

Constitutionally iron is invaluable, and perhaps the most readily assimilable form is the chloride, which may be given in the form of the tincture, x–xxx m. for a dose.

Septic Lymphangeitis.—The introduction of micrococci and bacteria into the open-mouthed lymphatic capillaries, is undoubtedly the cause of septic lymphangeitis, which, although a condition common to many diseases, has its origin from different infections; as for example, in vaccinia, smallpox, diphtheria, erysipelas, glanders, etc.[3] Septic lymphangeitis is the precursor of septicæmia.

The most frequent form of septic lymphangeitis is that following dissection wounds. The inoculation of virus from a dead body is not of necessity through a scratch or a cut, but in many instances undoubtedly by endosmosis; and it is remarkable how different, as to mildness or severity, the results of such an inoculation may be, this depending upon the condition of the poisoned individual, upon the nature of the poison, and upon the quantity of poison absorbed. Thus, an inoculation which in one individual may cause a simple lymphangeitis, in a second may be fatal. The atmosphere in which the poisoning takes place, and the previous state of health of the recipient, must also have a marked influence on his general condition. This has been frequently observed, especially in dissecting or post-mortem rooms, in men infected from the same body; and in one case in particular, of four men thus infected, one died from pyæmia, two were most seriously ill, whilst the fourth escaped with little or no further trouble than a simple lymphangeitis, the mischief being confined to the lymphatic system. In the other cases, we have an illustration of Burdon Sanderson's "pyrogenic" condition, in which the gravity of the septicæmia is in direct proportion to the amount of septic material introduced.

It is impossible to determine at what period a body becomes infectious; and as regards the changes which must occur, Dr. Roberts[4] remarks, that "under a certain occurrence of conditions in and about the wound (*if there be one*), a mortification takes place in the vital endowments of the septic organism, whereby it acquires a parasitic habit which enables it to breed in tissues of degraded vitality, or even in the healthy tissues, and in this way to produce the infective endemic pyrexia which we sometimes witness in the wards of our large hospitals." (See Erysipelas.) Bradley, in a lecture on septicæmia (May, 1876), gives as examples the following graphically described

[1] I can testify from personal experience that this remedy acts like a charm.

[2] The early application of Lister's dressing has, in several cases under my care, speedily cut short what might have been serious consequences, and in the suppurative stage the injection of a three per cent. solution of carbolic acid into the neighboring tissues, has been most efficacious.

[3] As erysipelas and glanders have been separately treated of, neither is described in this article.

[4] On "contagium vivum." British Medical Journal, 1877.

cases of lymphangeitis, illustrating the difference between two forms of septic inoculation from dissection wounds. The first is from his own personal experience, and accurately describes what many of us have suffered.

In December, 1871, I pricked my finger one day while dissecting, but took no notice of the puncture at the time; in the night following the accident I awoke with violent pain and throbbing in the finger and up the arm. I tossed about till daybreak, when I saw two thin, red streaks on my arm, running from the finger to the elbow. The pain was extreme, thirst excessive. Temp. 102°. A tender, enlarged gland could be felt just above the inner condyle. During the day the pain and red line extended up to the axilla; there a second tender and swollen gland made its appearance. The symptoms deepened in severity for the next twenty-four hours, when fluctuation could be detected in the axillary gland. An incision evacuated half an ounce of pus, and somewhat relieved the pain, which, however, still continued severe. I had two or three rigors during the day, and vomited several times. On the third day I was decidedly easier, the red lines were fading, and both lymphatic-vessel and gland tenderness markedly subsided. The fourth day I was convalescent.

The second case was as follows:—

W. S., aged 44, pricked his thumb while dissecting a tiger for the museum, and two days afterwards began to suffer pain at the seat of injury. On the fourth day he called to see me, when I found a small quantity of thin fluid discharging at the root of the thumb nail. The lymphatics were perceptibly affected, skin cold, tongue dry, pulse 100, but, perhaps, the most intolerable symptom was the intense mental depression I freely incised the thumb and sent him home to bed; this was on August 22, 1875. From this time his general condition grew worse until the 26th, when an ill-defined, or rather an undefined, abscess appeared in the cellular tissue of the arm. On this being opened, several ounces of pus were discharged, which lay loosely in the tissues, unconfined by any limiting membrane. Each day fresh abscesses of the same diffluent character appeared on the chest, abdomen, legs, and feet. He was very restless, and passed gradually from a condition of prostration into one of muttering delirium, which ended in death on September 11, twenty-four days after the reception of the poison.

To these cases might be added that of a London physician who died four days after the reception of a prick from a needle, in sewing up the abdomen after a post-mortem examination. In the case of a colleague, without any external wound, subpectoral suppuration occurred within a day of feeling unwell, diffuse suppuration in the axilla and lateral pectoral region ensued, with some pleurisy, and intense depression. He recovered, after free incisions, drainage, and removal to fresh country air, with the singular complication of partial paralysis of the serratus magnus muscle, owing to the implication of the nerve of Bell in the inflammatory process. Recovery was, however, complete, and the muscle resumed its normal functions.

The above quoted cases illustrate the fact that the development of symptoms in septic lymphangeitis is often slow, possibly owing to the slow nature of the lymphatic circulation, as may be instanced in syphilis, in some cases, where weeks may elapse between the appearance of the primary lesion and that of general symptoms; on the other hand, the writer has seen cases of syphilis where severe secondary symptoms occurred within one week of connection. According to some, the so-called gonorrhœal rheumatism is a septic lymphangeitis accompanying gonorrhœa (or subsequent to it), having, in strumous subjects, an undoubted tendency to suppuration.

Uterine Lymphangeitis.—Injury to the mucous lining of the uterus, generally puerperal, will originate a lymphangeitis of great severity, rapidly extending to the pelvic cellular tissue; although the septic material is as frequently introduced during labor, either by the infected fingers of an attendant, or by the atmosphere in which labor takes place. Recognizing the peritoneum

in its relation to the lymphatic system, we can readily understand how disposed it is to lymphatic infection, and that diffuse peritonitis rapidly follows such infection from various sources.

Puerperal peritonitis, like lymphangeitis, may be simple or septic (pyæmic). The simple form is a local inflammation, owing to traumatic causes during delivery, is non-contagious, and not invariably fatal. In the septic form "the process extends or may be traced, anatomically, through the lymphatics which convey the material they take up to the blood, and in this way excite inflammatory processes in the large lymph spaces, and more particularly the peritoneum . . . and is to be regarded as an accidental disease of a wound, a pyæmic disease, in which the septic matter is first taken up by the lymphatics and conveyed onward by them; on the blood taking up the putrid (bacteric) material by the lymph vessels, there arises a general infection—an actual septicæmia." (Bauer.)[1]

Curnow[2] remarks that,

> "Uterine lymphangeitis has been generally confounded with uterine phlebitis. In puerperal cases the two affections may exist side by side, but they can be easily distinguished. The cavities filled with pus in the uterine tissue in such cases are frequently lymphatic ampullæ, and not true abscesses. This is shown by the seat of the vessels, the smooth wall of the cavity, and the fact that the pus is quite white, or cream-colored, without any admixture of blood. Indications of valves in the cavity, and the absence of metastatic abscesses in the lungs and liver, as well as the extension of the disease to the adjacent glands, prove that the lymphatic system may be quite as much involved, if not more so, than the venous. In cases of so-called peri-uterine cellulitis and pelvic abscess, the following is frequently the sequence of the phenomena. In the first place there is a wound of the uterine mucous surface, engorgement, and inflammation of the lymph sinuses, leading to the formation of pus, and extension, either direct or by the cellular tissue, to the peritoneum. The inflammatory exudation is particularly noticeable where the cellular tissue is abundant—viz., in the broad ligaments and around the vaginal cul-de-sac. It may spread to the iliac fossæ and even to the lumbar region. In all these situations the lymphatics are very numerous. Sometimes the ovary is involved in the suppuration, and this is explained when we consider that the body of the uterus and the ovaries have a common lymphatic system. Peri-uterine cellulitis is really often a peri-uterine lymphangeitis with infiltration into the surrounding connective tissue, and corresponds exactly to some cases of lymphangeitis in the extremities. It may, of course, extend to the peritoneum, and undoubtedly there are many cases of primary pelvic peritonitis."

With regard to the *treatment* of septic *uterine* lymphangeitis, there is little to be said; it is invariably fatal, and we can merely add that strict antisepticity must be adopted as a prophylactic. As regards the general treatment of septic lymphangeitis, however, opium or turpentine stupes are of great value locally, in subduing pain, and perhaps the injection as a germicide of a saturated solution of carbolic acid may be of service; but the most valuable remedies are fresh air, quinine,[3] opium,[4] iron, and ammonia, with the antiseptic opening of abscesses as they occur.

The strength must be supported by the use of beef-tea, brandy and egg mixture, and other stimulants, so regulated as the condition of the patient suggests.

[1] Bradley, op. cit., pp. 90–1.

[2] Gulstonian Lectures, 1879.

[3] In doses of from ten to fifteen grains, to reduce the temperature.

[4] As a subcutaneous injection of morphia.

## Adenitis.

(Synonym: *Lymphadenitis.*)

After considering the inflammatory processes connected with the lymphatics themselves, we naturally pass on to a consideration of the inflammatory conditions of the lymphatic glands. Though they may be independently affected, they are, as a fact, most generally involved together with the vessels.

Any irritation may produce a simple adenitis; given a slight contusion of the gland itself, or of a finger or toe, or a pricked finger, not necessarily with a dirty instrument, and inflamed axillary glands may be the result, and, according to the severity of the local inflammation, so will be the pyrexia.[1] In all cases where adenitis occurs, there is a tendency to suppuration. If we examine any gland in which there is threatened suppuration, we may detect either a softening immediately superficial to the gland, or a general softening of the gland itself, indicating the usual condition of central suppuration. The whole reticular structure of the gland becomes choked with pus; and the circulation within it becomes stopped. Hence we may see a mechanical process whereby a gland in such a condition, or one which may have been so affected, may itself become a barrier against the further passage of septic or malignant material. The implication of a series or mass of glands will necessarily induce an œdema of the parts beyond, which may be either transient or permanent. Thus we frequently meet with œdema of the lower limb after adenitis of the glands of the groin, and even if suppuration has not occurred, glands may become permanently enlarged, and their condition, according to the state of the individual's health, induce a form of chronic œdema of the leg or thigh. Such a case has been recently under my observation, where syphilitic bubo, contracted many years previously, left the glands in the groin in this condition, and the parts became liable to chronic enlargement, and the limb to œdema.

*Symptoms.*—Whether the adenitis be simple or the result of septic material absorbed, the symptoms are much the same, differing only in degree. In the acute stage there are swelling and tenderness, and lancinating pain aggravated by any movement, accompanied by pyrexia, which is more severe, perhaps, in proportion to the nature of the material absorbed, and, as before stated, of the "soil" in which it is absorbed. The cellular tissue external to the affected glands becomes involved, and the integument over it glazed and red. Resolution may occur, but almost invariably suppuration follows these conditions. The abscess bursts, or is opened by the knife, and in most cases a cure is effected; but occasionally the suppuration is chronic, and sinuses form, burrowing amongst neighboring glands and the cellular tissue, excessively difficult to heal, and often showing no tendency to do so. The clinical condition of syphilitic bubo has been already discussed in the article on syphilis (Vol. II. p. 447).

*Treatment.*—In simple adenitis, the first point is to secure absolute rest, with leeches to the inflamed region, if necessary, warm fomentations or poultices, and, if suppuration occurs, free incision. Some speak highly of the

[1] Lymphadenitis is the most regular attendant on inflammatory processes of all kinds; this is dependent on the "retentive" function of the glands themselves. In the central reticulum of lymph glands, the material portions of the lymph are, as it were, arrested, brought thither by the affected vessels, and may be either innocent or of pathological import. Thus the materials used in tattooing the arm have been observed in the central reticulum of an axillary gland. (Virchow.) Hence it can be readily understood how pus corpuscles or bacteria can be arrested in the gland substance. A stasis naturally occurs, and coagulation of the lymph; and the characteristic hardness dependent thereon commences.

early use of antiseptic lotions. After the complete evacuation of the pus, the wound should be dressed with glycerine and carbolic acid (1–8), and afterwards, when the suppuration has subsided, with iodoform, 1 part, cerat. cetacei, 7 parts; and light pressure with a spica bandage should then bring about a cure (Bradley). Hueter speaks highly of the early injection into the glandular parenchyma of carbolic acid (3 per cent. solution), but I have had no experience of its efficacy. In some cases a peculiar undermining of the integuments occurs, when the burrowing sinuses, with no disposition to heal, must be slit up, and the tracks treated by caustics antiseptically. Scraping away the granulation tissue by means of Volkmann's spoon is frequently of value, and, if large surfaces be exposed, they may be conveniently covered by Reverdin's plan of transplantation of cuticle. The writer has found terebene of great value in this condition after buboes in the groin.

The proper treatment of the caseous infiltration of glands is their total extirpation. In cases of chronically enlarged, painful glands, the injection of a few minims of tincture of iodine by means of a subcutaneous syringe will frequently bring about absorption. Pressure by means of a well-adjusted truss has been tried with good results.

## Varicose Lymphatics.

(Synonyms: *Lymphangeioma; Lymphangiectasis.*)

Owing to the difference in the anatomical arrangement of the reticular and tubular lymphatics, there are differences in the dilatations of the trunks and networks. The dilatations of the latter are most frequently observed on the inner aspect of the thigh, the external genitals, and the side of the abdomen. The condition is readily diagnosed; the little boiled-sago-like eminences, which are translucent vesicles, are readily emptied by pressure, and when punctured exude lymph. Dilatations of the superficial trunks are more frequent than those of the réseaux, and differ in appearance, inasmuch as they are, as might be expected, ampullary in shape, and are almost invariably associated with œdema of parts below the tumor. As far as regards the varicose condition of the deeply-seated lymphatic trunks, there can be little doubt that it is the starting point of the lymphangeioma, a comparatively rare condition closely allied to the angeioma, only that the fluid contained within the mesh-work is lymph instead of blood.

Cystic dilatations of the lymphatics are usually found in the tongue (*macroglossa*), in the lips (*macrochilia*), and in the neck (*hydroma*). They have, however, been met with in other parts of the body, such as the axilla and groin.

With regard to macroglossa, there would seem to be a lymphangiectasis, then a lymphangeioma, and then its transition into an angeioma, when the bloodvessels proliferate in the lymph spaces. In macrochilia there is a preponderating development of the lymph vessels. It is a pale, very soft swelling, and can be easily emptied by pressure. The hyperplasia affects the mucous membrane more than the entire lip substance. I have observed, on one or two occasions, a curious blubber-like œdema of the lips following exposure to cold or damp weather, the lips protruding in such a manner as almost to render the individual undistinguishable. This has been in persons of the so-called lymphatic temperament, and has subsided of its own accord. With regard to the cystic hydroma of the neck, Busey states that "Billroth, Lücke, Köster, and others, have classed the congenital cystic hydroma of the neck among the cavernous lymphangeiomata. These consist (Weichselbaum) of connective-tissue trabeculæ, within whose branches and intercommuni-

cating caverns a serous fluid is contained. This form of congenital cavernous formation occurs most frequently amongst females, has been usually observed in immature children, and is generally complicated with other malformations. The tumor always (Steinwirker) has its principal seat at the lower portion of the occiput and upper part of the neck, is spheroidal, with a smooth surface, and is divided in the median line of the body by a furrow, into symmetrical halves." It is "usually composed of two symmetrical cysts, divided into smaller compartments. The cysts are lined with characteristic lymphatic endothelium, and contain serum. Köster has proved the direct transition of the cysts into ampullary canals and spaces, and has recognized the connection of the latter with the sinuses of lymph glands." These cystic lymphangeiomata are not as often the seat of lymphorrhagia as the more common forms. Lymphangeiomata have been frequently observed in the groin. The tumor is about as large as the fist, soft to the touch, and when grasped feels like a bag of worms; and it may also be mentioned that this region is liable to lymph-varix and lymphorrhœa.

## Elephantiasis Arabum.

This disease[1] is essentially lymphatic in its character. Its relation to repeated attacks of erythema is noticeable, and the hyperplasia of the integuments, following a swelling of the lymph glands, ultimately becomes developed into the condition thus named. Virchow classes elephantiasis amongst the fibromata, and describes it as a diffuse new growth, chiefly in the subcutaneous cellular tissue, but sometimes developed in the papillary bodies. New light has recently been thrown on its etiology by the discoveries of Manson, Lewis, and Bancroft, and their investigations show that it is in all probability caused by a hæmatozoon, the *filaria sanguinis hominis.* By its presence in the lymphatics, exudation, œdema, and ultimately organization of the exuded material take place. Sir Joseph Fayrer[2] gives the following as a general definition of the malady: "Elephantiasis (Arabum) is a non-contagious disease, endemic in certain localities, generally intertropical, and near the seacoast, characterized by recurrence of febrile paroxysms attended by great suffering, inflammation, and progressive hypertrophy of the integuments and areolar tissue, chiefly of the extremities and genital organs, and occasionally by swelling of the lymphatic glands, enlargement and dilatation of the lymphatics, in some cases by the coexistence of chyluria, and the presence in the blood of certain hæmatozoa; the hypertrophy of the integuments resulting in enormous enlargements of the extremities, scrotum, or labia, accompanied by an albuminous deposit in the cells of the areolar tissue, and by degeneration of the muscular and osseous tissues."

This disease must not be confounded with Elephantiasis Græcorum (true leprosy), although, according to Richards and others, they may coexist.

The onset of elephantiasis is frequently violent, and attended with great suffering. There is high fever, intense pain in the lumbar region, groin, spermatic cords and testes, which become much congested and swollen, whilst acute hydroceles form. This is often attended with sympathetic vomiting, nausea, rapid and erythematous swelling of the external parts; and if the extremities be attacked, the swelling is often very tense and painful, accompanied by much effusion into the areolar tissue. The surface of the integument is much inflamed, and sometimes discharges a serous ichor or chyle-like fluid, according to the extent to which the lymphatics are involved in the particular case. There is much constitutional disturbance, increase of temperature, and often depressing

[1] For the statements in regard to elephantiasis, I am largely indebted to the works of those who have had abundant experience in a disease but rarely met with beyond the tropics.

[2] Trans. Path. Soc. London, 1879.

nausea and vomiting when the cords are implicated; when the great tension and swelling of the cords is apt to dilate the abdominal rings so widely that, when it subsides after recovery, the patient is liable to suffer from hernia through the widened inguinal passages.[1]

The general appearance of a portion of the body in an elephantoid condition is that of an enormous hypertrophy of the fibrous elements of the skin, with a copious albuminoid deposit in the cells of the areolar tissue, and great increase in size and prominence of the papillæ. The whole integument is thrown into warty-looking, rugose folds, overhanging or overlapping, precisely like the elephant's integument, and in many positions, as in the scrotum or labia, utterly concealing the true nature of the parts. The term elephantiasis should, according to Fayrer, be limited to the "constitutional form of the disease, that occurs within certain endemic areas, and which is manifested by paroxysmal febrile attacks, accompanied by a disturbed condition of the lymphatic system, chyluria, hæmatozoa, and progressive inflammatory hypertrophy of some portion of the tegumentary system."

As regards *treatment*, no constitutional means have had any beneficial result beyond checking the excess or severity of the febrile paroxysms. It seems that change of climate is a potent remedy in early stages of the disease. As we have to deal more particularly with the surgical aspect of elephantiasis, we may here consider what operative treatment can be brought to bear on such cases.

*Removal of the growth* not only relieves the patient of the terribly fetid mass, but also relieves him of the accompanying fever, which ceases after the growth is taken away. The most favorable cases for entire removal, which, under these circumstances, gives excellent results, are those of scrotal and labial tumor. The introduction of Esmarch's bandage has rendered the operation bloodless and safe. Before undertaking the removal of a scrotal elephantiasis, the patient should be placed on his back, so as to drain the mass from blood for an hour or so before operating. The neck of the tumor should then be compressed by a modified Esmarch's bandage, and the removal proceeded with. Application of pressure on the abdominal aorta is advisable.

Incisions should be made along the dorsum penis and course of the spermatic cords. The cords, testes, and penis are dissected out, reflected, and held up on the abdomen, while the mass is severed from its perineal attachments. The vessels are tied with scrupulous care, and the wound is dressed with carbolized oil and antiseptic dressing. The wounds heal by cicatrization. Such tumors have been found after removal to weigh as much as 110 pounds.

*Ligature of the main artery* of a limb, in such cases as elephantiasis of the leg or arm, is useless, and if any good be done it is only temporary. We are largely indebted to the experience of Sir J. Fayrer for what is at present known of the pathology and treatment of this disease, which is rarely met with beyond the tropics, although isolated cases have been observed elsewhere; a detailed account of the microscopical appearance of the tissues involved, in two specimens presented by that surgeon and Dr. D'Arcy Power, will be found in the Transactions of the Pathological Society of London for 1879, pp. 499–503.

## Lymphadenosis.

This affection of the lymphatic glands has received various names, and indeed even now the nomenclature of the results of the diathesis thus desig-

[1] Fayrer, Trans. Path. Soc. London, 1879, p. 496.

nated, is rather unsettled. Formerly, the affection was termed Hodgkin's disease, progressive glandular hypertrophy, adenia, or pseudo-leukæmia, and the growths were called lymphomata, or vascular sarcomata of the lymphatic glands. We, however, generally adopt the term, "malignant lymphoma," of Billroth, or "lymphosarcoma," of Virchow. Wunderlich appears to have made the first accurate clinical observations on the disease, whilst Virchow assigned to it its pathological position, and Billroth first opened prospects of successful treatment based on his histological researches (Birch-Hirschfeld). We must regard lymphadenosis as a true diathesis, and one marking the lymphatic diathesis in its most "accentuated" form. Primarily a disease of the lymphatic system, it is characterized by the enlargement of groups of glands, or of the entire glandular system. There is always anæmia and absence of tendency to suppuration. It would seem that it is only in isolated cases that the disease is primarily developed in already swollen glands, and in the majority of cases the absence of the scrofulous habit is expressly noticed, the disease making its appearance, as a rule, at a later age than scrofula.

As regards the locality of the affection, we find that the hypertrophy generally commences in the cervical or submaxillary glands, or in the glandulæ concatenatæ. Occasionally the disease commences in the axillary, inguinal, or mediastinal glands, but more frequently these glands enlarge by subsequent invasion. I have now under my observation a man whose cervical glands are so enormously enlarged that it appears as though the face was "peeping" out of the mass, which has been of very rapid growth; the axillary glands are becoming clearly affected. The hypertrophy is generally painless, unless nerve trunks be involved at once, and the glands are very slow to suppurate or degenerate; occasionally, however, they have been known to undergo caseation. At first there is a slow failing of health, in no way marked, but when all the glands are involved the general health begins to suffer; increasing anæmia follows as the disease progresses, the patient, unless some vital part be affected, finally dying from exhaustion. As a rule, the disease proves fatal within two or three years of its first appearance.

When death does not occur under the influence of a local affection of this kind, and extraordinary development, or by the appearance of some grave complication, cachexia of the severest degree ensues. The anæmia becomes so prominent that Wilks named the disease after this symptom *anæmia lymphatica*. . . . In the last period of the disease, insomnia is a frequent symptom (sometimes, on the contrary, somnolence is present), the appetite is completely lost, profuse diarrhœa sets in almost without exception, dropsical symptoms appear, bed-sores form, and finally the patient sinks into collapse.[1]

SYMPTOMS OF LYMPHADENOSIS.—With regard to the *symptoms* of lymphadenosis, in the present state of our knowledge we can hardly expect to recognize it until glandular hypertrophy exists, and, of course, when commencing in parts where we cannot palpate, the nature of the disease must remain totally obscure. It is usually quite painless, but is occasionally associated with great pain. In a case under my notice at present, the tumor is growing beneath the upper part of the sterno-cleido-mastoid muscle, and causing intense pain to the patient, who is about twenty-five years of age, and has marked pyrexia. (According to Gowers, pyrexia is present in two-thirds of the cases.) There is no *characteristic* change, however, in the temperature: in the earlier stages there is no fever, but afterwards the evening temperature is higher, and sinks below normal before collapse. Anatomical considera-

[1] Birch-Hirschfeld, Ziemssen's Cyclopædia, vol. xvi. p. 835.

tions, as to pressure or irritation, are, of course, of value in determining the course and character of this disease.

Progressive anæmia is always associated with the hypertrophy of the glands, wherever situate, accompanied with sweating, nervous depression, and often syncope. As regards the condition of the blood, there is, perhaps, no increase in the white corpuscles, though the red are much diminished, and it is so much paler in appearance than normal blood, that Gowers has compared it to "diluted claret." We invariably observe mental depression or hysteria in these cases.

Diagnosis.—The *diagnosis* of lymphadenosis is not always easy. We have to differentiate it from cancer, scrofula, and leucocythæmia, and in the outset of the disease the diagnosis is probably impossible. In lymphadenitis, as before stated, on examining the blood, we find that the red corpuscles are diminished in number, while the number of the white corpuscles is unchanged, although we may have *leucocythæmia* coexistent, as instanced by general lymphatic enlargement and an increased number of white corpuscles.

In the diagnosis from *struma or scrofula*, which again may be coexistent, we may be guided by the marked absence of the tendency to periadenitis, suppuration, or degeneration and softening, which we always meet with in enlarged strumous glands. These glands in struma, rarely, if ever, attain the enormous size they do in lymphadenitis, and are slower in growth; moreover, a few only of a group of glands are affected, whereas in lymphadenosis the gland invasion is general, and there is an absence of the nodular, hard, banded masses so noticeable in struma.

In its differentiation from *cancer*, which is rarely a primary glandular affection, we notice that lymphadenosis is invariably so; we also observe its early development, the freedom of movement of the superficial integument, and the presence of splenic or thyroid mischief; and on microscopic examination we find that the cell growth is lymphoid in lymphadenosis, and epithelial in carcinoma.

The diagnosis between *sarcoma* proper and malignant lymphoma is of importance, since in the latter extirpation of the gland holds out no chance of success, whereas a timely removal of a sarcomatous gland may do so. The essential difference, according to Winiwarter, "seems to be the fact that lymphoma consists of a hyperplastic process, while such tumors only are to be regarded as sarcomatous, as in type have nothing in common with the mother tissue." Sarcoma extends directly to neighboring tissues, and is liable to retrograde metamorphosis and ulceration.

Anatomically, we may distinguish two forms of malignant lymphoma, the *hard* and the *soft*, but, as originally suggested by Virchow, there does not appear to be any *clinical* difference between them. The distinction, indeed, according to Langhaus, is not accurately definitive, for we may meet with a mixed form in the same individual. In the soft form, as far as it interests the surgeon, the several glands forming the group can be readily made out; the integuments, as a rule, are non-adherent, and glide freely over the mass, and it is very rare to find the growth invading neighboring tissues. With regard to the microscopic appearances of these two forms, it would seem that "there is no essential contrast between them; in the *soft* form the cell formation is more abundant, and the new formation preserves mainly the embryonic character, while in the *hard* form the new growth undergoes a species of fibrous metamorphosis." (Birch-Hirschfeld.)

Wilks places lymphadenosis clinically between tubercle and cancer, and Gowers says, that "in order to explain the phenomena of Hodgkin's disease,

it is necessary to assume the existence of a general dyscrasia affecting the lymphatic tissues, of different intensity and different operation in different cases, but existing in all."

PROGNOSIS.—As to the *prognosis* of this disease, we must at present regard it as exceedingly unfavorable, almost equally so with cancer. According to Bradley,[1] there would seem, however, to be a tendency to exaggerate the gravity of the malady in its earlier phases. "If the spleen be not implicated, if only certain groups of glands be affected, *e.g.*, the cervical, axillary, and inguinal, and if the temperature be normal and steady, a fairly hopeful prognosis may be given. . . . If, on the contrary, the spleen be much enlarged, if there be leucocythæmia, if the thoracic and abdominal glands participate in the disease, or, and this is a point to be especially attended to, if the temperature be high and irregular, the prognosis is exceedingly bad, indeed, may be said to be uniformly fatal." Therapeutics, however, latterly seem to have afforded some good results.

TREATMENT.—As regards surgical treatment, it is usually hopeless, and even in the earlier stages it is but of little avail. All local sources of irritation should be removed, and careful attention should be paid to the hygienic condition of the patient, while as remedies, cod-liver oil, iodine, and phosphorus may be administered. Arsenic appears to have been of great value in the form of Fowler's solution, and is highly spoken of by Winiwarter, Czerny, and Billroth. Cold, injections, counter-irritants, caustics, pressure, massage, écrasement, and electricity, would seem to be invariably useless, and often dangerous.

If removal be decided on, and I confess the chances it incurs are about on a par with those of the attempted removal of any malignancy,[2] the incision, or incisions, to expose the growth must be carefully planned. The operation may be very easy or very difficult, but if the capsules of the glands are not adherent or softened, the removal is practicable. We must cut down on the tumor, giving free room for the use of the fingers, and indeed, after the primary incision, we must depend upon "tearing," or enucleation; bleeding vessels must be tied as we proceed, and the operation resolves itself into a process of "digging." I removed an enormous mass of these glands (cervical) some time since in the Charing Cross Hospital, and it seemed that the more we took away the more there was to remove. There was but little hemorrhage, and the patient for a while did well, but the return was as speedy as if the mass had been medullary. As far as the utility of removal goes, excision would seem to be merely practice in operative surgery, and an exhibition of manipulative skill, and sometimes of daring. Unless the disease is attacked very early, an operation is quite useless.

## CONDITION OF THE LYMPHATICS IN SYPHILIS.[3]

The introduction of the syphilitic virus into the system takes place either by abrasion, by puncture, or by absorption through the mucous membranes or cuticle, without the presence of any actual lesion.

[1] Op. cit., p. 119.

[2] But, as Billroth says, destruction or extirpation of the glands is "still more worthy of recommendation, if the modern views as to the origin of tuberculosis should prove true, viz., that every caseous area, especially if it exist in a lymphatic gland, may prove to be a source of danger." (Billroth, Clinical Surgery, p. 151. London, 1881.)

[3] This subject is more fully discussed in the article on Syphilis.

In all probability the syphilitic virus is a *contagium vivum*, and although it has not as yet been definitely determined microscopically whether the bodies seen are germs (micrococci), it would seem, from the manner in which the virus travels in experimental inoculations, that they are so.[1] The chain of events after inoculation, seems, in general, macroscopically, to be very analogous to that occurring after any inoculation with septic matter, but the *action* of the poison is specific. After the appearance of the chancre or initial lesion, we find the entire lymphatic system "showing up," as it were, the invasion of this peculiar virus. There is a period of latency, the cell proliferation is slow and slight perhaps, but the general infection is entirely due to the lymphatic system.

Some time after the inoculation, the period varying greatly, the course by which the poison reaches the neighboring glands may be shown by a cord-like thickening of the ducts. This is distinctly observable on the dorsum penis, or, in the case of the mouth, in ducts leading to the buccal and labial glands; in the case of the mammæ, in those leading to the superficial axillary glands. With regard to the changes taking place, Von Biesiadecki[2] "found the muscular fibres in such lymphatic vessels enlarged, through the presence of numerous exudation cells; the adventitia was contracted, containing only a few of these cells; the vessel was in places plugged by a coagulum, or closed by a thickening and folding of the intima. The immediate vicinity of the lymphatic vessel was but little changed; rarely a few exudation cells appeared between the fat cells." Neighboring glands become slowly affected, a condition never observable before the primary affection, but usually from the eighth to the eleventh day; in a case observed by myself, of a student inoculated from a midwifery case, the supra-condyloid gland was enlarged in seven days, and the axillary glands in fourteen. Bäumler, quoting Rindfleisch,[3] observes that *histologically* these glandular swellings represent *a hyperplasia of the cellular gland elements*, and the chronic induration of the glands is due, not so much to a hardening and enlargement of the reticulum, as to a very uniform, though by no means exuberant, growth of young cells in all portions of the gland. The involution is effected through fatty metamorphosis and absorption. Under certain circumstances caseous and calcareous degeneration may take place. In course of time the poison reaches the thoracic duct, and is poured into the bloodvessels, to be speedily followed by a specific fever, with a characteristic eruption.

Those structures of the entire system which are essentially lymphoid evince the peculiarities of their invasion. The tonsils enlarge and ulcerate. The posterior cervical glands enlarge, and in many instances the condyloid glands of the elbow; and in the cellular tissue of the viscera, which is largely composed of lymphatics, we find the later and more important lesions of syphilis. A portion of the poison circulating in the blood gives rise to the cutaneous *syphilides*—an effort at elimination; a greater part still continues to travel along the lymphatics, and gives rise to the characteristic glandular and visceral lesions elsewhere described. In the tertiary form of the disease we find no hardening or thickening of the glands, but what has been termed by Collin a "catarrhal" affection.

## Cancer of the Lymphatics.

As the whole subject of cancer will be dealt with in the article on Tumors, it is proposed to do little more than allude to the condition in the present place.

1 Some researches by the author, now going on, are not ready for publication.
2 Ziemssen, op. cit., vol. iii. p. 117. Quoted by Bäumler.
3 Ziemssen, op. cit., vol. iii. p. 120.

Although the materies morbi of cancer is well known to traverse the lymphatics, yet primary carcinoma is very rarely, if ever, met with in the lymphatic glands. Billroth is decidedly of opinion that primary carcinomatous affections of the lymphatic glands are of very rare occurrence; but as they are the parts which give passage to the fluids of the tissues as they pass on their centripetal course, a strict separation would only be possible where heteroplastic new formations were found in the lymphatic glands;[1] and Paget states that, as a primary disease, scirrhous cancer of the lymphatic glands is very rare, the cancer which most frequently appears first in them being the medullary.[2]

There would appear to be but little doubt that the *epitheliomatous* form of carcinoma is invariably of epithelial origin, the epithelial cells being most like the parent cells of the cancer cells, and it is readily seen how epithelial elements would select the lymph-channels for their passage, owing to their intimate association with the mucous membranes and skin and cellular tissue. The actual passage of cancer cells along the ducts has not been often observed, but when the glands have become infected, the afferent vessels have always been found loaded with cancer cells; and it is more than probable that the cancer juice, or altered cells, is sufficient to induce infection, since we find that the secondary growths are precisely similar to the primary.

A study of carcinomatous tumors of the breast, from their frequency and position, affords a field of research on the peculiarity of the invasion of this neoplasm. The views of Creighton[3] seem to point out that the secondary infection of the glands is caused by pigment cells, which either act upon the lymphoid cells, or undergo rapid self-multiplication. This would seem to be borne out by the experiment of engrafting the cuticle of the negro into a granulating sore on a white man, when it was found that the pigmented character of the cell was communicated to all the newly-formed cicatricial cells of which the dark cells were the parents.[4]

Dr. Hoggan's views[5] with regard to the mode of infecting lymph glands with cancer may be briefly stated as follows:—

Using the word cancer in the general sense (scirrhus), amongst the most important of these conclusions are the following:—

"As soon as the lymphatic glands become affected, all the lymphatic vessels between them and the morbid part become filled with a plug formed of cancer cells. . . .

"Contrary to expectation, the lymphatic vessels on the distal side of the tumors become also filled up with a plug of cancer cells. This is due, apparently, to the impaction and accumulation of lymph or wandering cells coming down with the lymph stream against the distal ends of the cancerous plugs in the already occluded lymphatics, and there they themselves become cancer cells by contiguous infection. . . .

"By prolonged exposure to the contagion of the plug of cancer cells within the lymphatics, the endothelial cells, which form their sole wall, become cancerous, and their nuclei begin to swell and become more pellucid, while, although the cells retain their shape and position, they seem to change their nature." . . . "The one thing needful for the development of secondary cancers from the lymphatics is the presence of groups of wandering cells in close proximity to cancerous lymphatic walls." . . . "When a lymphatic or wandering cell becomes infected, it gradually increases in size in all its elements, and if originally irregular in form becomes egg-shaped. The cell substance proper (protoplasm?) becomes more pellucid and refuses to stain with colors, appearing to become vacuolar, which, however, it does not, but rather reminds one of the external swelling undergone by a pellet of hard gelatine when it is first steeped in water.

[1] Billroth, op. cit., p. 162.
[2] Paget, Lectures on Surgical Pathology, p. 609. 1863.
[3] On the Physiology and Pathology of the Breast.
[4] Bryant, Manual of the Practice of Surgery, 2d edition, vol. i. p. 163.
[5] Transactions of the Pathological Society of London, 1878.

This swelling goes on until the cell has reached a comparatively enormous size, when the substance proper seems to melt away as a fluid, thus freeing its nucleus (or nuclei), which now becomes the actual cancer cell. . . . The nucleus of the wandering (or lymph) cell, now itself become the cancer cell, may increase in size to above 200 times the size of the original cell."

Gussenbauer, in an elaborate paper on the development of secondary tumors of the lymphatic glands,[1] is much of the opinion of Creighton and Hoggan, though modified. Histologically, his observations are evidently in favor of the theory that the tissues of the lymphatic glands are transformed, by infection, into a structure resembling that of the primary tumor. He mainly agrees with Hoggan, that the linear cords of new growths are not due to plugging of the lymphatic vessels by cells detached from the primary tumor, but to proliferation and transformation of the epithelium all along the lymphatic vessels by continuous extension of infection. He does not find that the *afferent* vessels or the peripheral lymph sinuses are occupied with transported cells or beginnings of new growths; but in the follicular tissue he describes a kind of corpuscular element, fertilizing germs (*befruchtende Keime*). They are carried by the lymphatics from the primary tumor, and infect constituent elements of the gland in such a way that they become transformed into the likeness of tumor cells. This is more particularly observed in the case of melanosis.

As a complex transformation of lymphatic gland forms, in the case of primary colloid of the rectum, Gussenbauer describes the change into spaces lined with epithelial cells containing colloid material. The epithelially-lined spaces are traced back through several stages, and ultimately identified as blood-vascular channels, whose epithelial, muscular, and other elements have taken on active proliferation, and ultimately the distinctive form and arrangement of the cells lining a glandular tube.

Particular attention is called to the fact of the participation of the various coats of the bloodvessels in the formation of the secondary new growths.

Clinically, as to the detection of non-infiltrated, infiltrating, or infiltrated glands, there is obviously great difficulty in the early stages of the disease. We know well that in the normal condition, glands vary much in size in the quite healthy individual, and the advice of the surgeon, in cases of cancer, is rarely sought until the affection has made headway. If we take, for instance, the breast, whence most of the clinical investigations have been made, we find that almost invariably, at the time of examination, the glands are involved—an aid to diagnosis, truly, but greatly against our success in operation. The great clinical question to be answered is, "When do the glands become affected?" and any statements as to the rate of infection would be of the greatest clinical value. Any enlarged lymphatic gland in the neighborhood of a cancer must be regarded with suspicion, and treated accordingly; hence the necessity of emptying the axilla of its glands in excisions of the breast.

To briefly summarize what has been said, we may, from what we know at present, assert that, as far as the infection of the lymphatic system is concerned, syphilis is a virus, possibly a "contagium vivum," invading the lymphatics; and that cancer is a dyscrasia (perhaps hereditary), which by means of the connective tissue involves a part or parts of the entire system. The term *epitheliosis*, as suggested by Bradley, seems to be a generalization of convenience. The question of visceral cancer and its relation to the lymphatic system will be found treated of elsewhere; those points which are of special interest to the surgeon have been alluded to in the present article.

[1] Zeitschrift f. Heilkunde, März, 1881. Ueber die Entwickelung d. sec. Lymphdrüsengeschwulste.

Bibliography.—The more recent accounts of the relation of cancer with the lymph system will be found in papers by Waldeyer, Die Entwickelung d. Carcinome, Virchow's Archiv, Bd. xli. S. 470; Gussenbauer, Ein Beitrag. z. Lehre v. der Verbreitung des epith. Krebs auf Lymphdrüsen, Arch. für klin. Chir., 1872; Id., Ueber d. Entwick. d. second. Lymphdrüsengeschwülste, Zeitschrift. f. Heilkunde, März, 1881; Billroth, Lectures on Clinical Surgery, 1882; Curnow, Gulstonian Lectures, 1880; Rindfleisch, Lehrb. d. path. Gewebelehre, 1875; A. v. Winiwater, Die allgemeine chirurgische Pathol. und Therap., 1880; Chambord, Du Carcinome primitive des Ganglions Lymphatiques; Kocher, Primäres Achseldrusencarcinom. nach chronische Mastitis; Creighton, Pathology and Diseases of Breast, 1879; Hoggan, Transactions of the Pathological Society of London, 1878, and Archives de Phys. Norm. et Pathologique, 1880.

# INJURIES OF BLOODVESSELS.

BY

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Bloodvessels are the musculo-elastic tubes and hollow muscles which receive, contain, and convey the blood in animals, and in man. They are naturally divided into three distinct groups or systems, whereof each is characterized by certain well-known features, namely, the *arterial*, the *venous*, and the *capillary;* together with a central organ, the heart. In this article, then, we shall have to consider, severally, the traumautic lesions of the *arteries*, the *veins*, the *capillaries*, and the *heart*, which may chance to require the attention of surgeons. But injuries of these vessels are of no especial moment to surgeons unless they cause, or are liable to cause, (1), *hemorrhage;* or (2), *destructive inflammation* of the injured vessel itself; or, (3), *gangrene* of the parts supplied or nourished by the injured vessel. We shall, therefore, have to discuss not only the several kinds or modes of injury to which the bloodvessels themselves are exposed, but, likewise, the hemorrhages, the vascular inflammations, and the gangrenes which experience has shown to result from these injuries.

### Surgical Hemorrhage.

Any effusion of blood from the vessels framed to hold it, whether attended with rupture (wound), or occurring without rupture (wound) of their walls, is, in the broad or unrestricted sense of the term, a hemorrhage. Now, such effusions of blood may, in respect to origin, be *spontaneous*, or they may be *traumatic*. The first belong, for the most part, to the domain of medicine; the latter, exclusively to the domain of surgery. But not all the extravasations of blood which are caused by injuries, and, therefore, are properly called traumatic, should be denominated examples of surgical hemorrhage. For instance, it is hardly worth while to dignify a simple ecchymosis of the skin, or a common "black-eye," by styling it surgical hemorrhage, although the discoloration is wholly dependent on the extravasation of blood from vessels ruptured by violence. So, too, with most, perhaps with all traumatic hemorrhages, that are essentially trivial and require no treatment. It seems clear, then, that the term surgical hemorrhage should be applied to those instances of the traumatic extravasation of blood, only, which are, *per se*, of such importance as to require surgical treatment, or which prove fatal in default of such treatment. But, there also are certain hemorrhages, which are not traumatic, that demand the employment of surgical measures for their arrest,

as well as the cases just mentioned. For instance, bleedings from the nose which necessitate the operation of plugging the nostrils; bleeding from ulcerations of the tonsils which penetrate the internal carotid artery, and make necessary the ligation of that vessel or its parent trunk; bleedings from abscesses which lay open the arterial canals of any part; bleedings from aneurisms about to burst, which can be controlled, if at all, only by surgical procedures, etc. Moreover, there are good reasons why these, too, should be called surgical hemorrhages; for they are, in fact, examples of surgical affections attended by bleedings that require surgical treatment. The term surgical hemorrhage, then, properly belongs to all bleedings that result from injuries, from surgical operations, and from surgical diseases, which need surgical treatment; and the expression should be strictly used to convey these ideas. When employed for this purpose, the phrase surgical hemorrhage is oftentimes very convenient and useful.

Importance of the Subject.—Notwithstanding the importance of "shock," hemorrhage is the most serious of all the complications attending wounds in general. More lives are lost from it, either directly or indirectly, than from all the other consequences combined, that flow from such injuries. Of the slain in battle during our War of the Rebellion, I can testify from personal observation that a very large share, about one-half I think, but possibly even more than that, perished by hemorrhage from wounds of the large bloodvessels of the neck, chest, abdomen, groin, etc., or from wounds involving vital organs like the brain and lungs, the bleeding whereof caused deadly compression of these organs, before succor could be afforded.

In a great many wounds, the first thing needed is to stop the bleeding. In wounds generally, the symptom which most alarms the bystanders, the patient himself, and too often the surgeon also, is hemorrhage, and frequently it demands immediate attention. But to operate successfully for this complication, the surgeon must divest himself of all fear, "and learn to look boldly on the open mouths of arteries." This terse saying of Robert Liston should be graven on the memory of every one who aspires to become a surgeon. Now, it is highly befitting to know, and also to tell, how the student of surgery may divest himself of all fear in the presence of hemorrhages that are great, and by what means he may learn to look boldly on the open mouths of arteries that are large. Such spectacles naturally appal, and stupefy, and paralyze men, unless their minds have been so strengthened and prepared by special training and forethought that they can view them intelligently, and to some extent, also, consider them as experiments on the living human animal, accidentally performed, which nevertheless should be calmly and accurately noted, for the advancement of our knowledge. By special training and fore-thinking, then, the surgeon may acquire self-reliance to witness any hemorrhage without dismay, and to look on the open mouths of any arteries with complete self-possession. But to reach this end, his training must be continued until he gets an accurate and ready knowledge of the surgical anatomy of the bloodvessels; a complete knowledge of the symptoms and prognostics of hemorrhage itself; a thorough understanding of Nature's own hæmostatics; and, finally, a perfect acquaintance with the hæmostatics devised by surgical art. Amussat indeed thought that, in order to know how to arrest a hemorrhage, it was necessary to have tied the arteries in animal vivisections. The surgeon's fore-thinking should largely consist in scrutinizing the reported cases of hemorrhage in all regions of the body, in ascertaining the causes of success or failure, and in considering them with a view to devise, if possible, better plans of treatment; for reported cases of hemorrhage are, in reality, accounts of accidents which are liable to occur again.

He must continue to ponder in this way on the recorded examples of hemorrhage, until he thoroughly familiarizes himself beforehand with exactly what should be done in every class of cases and in every region of the body, together with all the exceptional occurrences. The late and highly-esteemed Dr. Otis justly observed: "It is hardly possible to unduly multiply illustrations of the management of wounded bloodvessels;"[1] and, no doubt, had the above-mentioned use of such illustrations in view when he penned the words. In brief, then, it is by thorough special training, and by patiently fortifying himself from the experience of past generations, that the surgeon acquires the boldness and positiveness, the promptness and dexterity, which are demanded in the treatment of wounded bloodvessels. But, if he have done otherwise, the anxiety and embarrassment which he manifests in the presence of hemorrhage will show how insufficient on this point his surgical knowledge and ability really are. Thus, it appears that the injuries of bloodvessels and their consequences are subjects of very great importance to both patients and surgeons, and that it is scarcely possible to make any discussion of them too thorough or elaborate.

Nomenclature of Hemorrhage.—Surgical hemorrhages are called *external* or *internal*, according to the situation or direction of the flow of blood in respect to the body at large, whether it be without or within the same; but they are mostly external. Internal extravasations of blood, however, are, upon the whole, more dangerous than those which are external.

Surgical hemorrhages are said to be *pelvic*, *abdominal*, *thoracic*, *axillary*, *cervical*, *brachial*, *femoral*, etc., according to the region of the body in which they occur.

Surgical hemorrhages are also described under the names of *urethral*, *renal*, *epiploic*, *gastric*, *hepatic*, *pulmonary*, etc., according to the organ that is wounded and bleeding.

Surgical hemorrhages finally are denominated, (1) *arterial*, (2) *venous*, and (3) *capillary*, according to the system of vessels from which the bleeding proceeds; and each of these varieties has much practical importance.

(1) *Arterial Hemorrhage.*—In arterial hemorrhage, the blood usually has a bright-red or scarlet color, and flows in a jerking stream, or *per saltum;* and the jets are synchronous with pulsations of the arteries themselves. Between the jets, however, the flow does not entirely cease; the stream is in reality a continuous one, whose volume is swollen by each arterial pulsation. This fact I have often noted in the arteries of the scalp, face, and extremities, when they were cut in wounds of these parts having such extent and form as to expose the open mouths to view; in wounds caused by accidents, and by surgical operations. The blood issues in jets, for the most part, from the proximal orifice only. The blood which escapes from the distal orifice is generally dark-colored, and flows in an even stream, like that which flows from wounded veins. But in some parts of the body, where the terminal branches of the arteries inosculate with exceptional freedom, the blood may issue in jets from the distal as well as from the proximal end of a divided artery; this occurrence I have often witnessed in wounds of the scalp and face, especially in those seated near the median line; I have also met with it in wounds involving the plantar and palmar arches, respectively, and in wounds of the forearm. When the blood escapes from the distal orifice in jets, it likewise retains the bright-red or arterial hue. When from any cause a vigorous hemorrhage continues, the jets soon become less strongly marked,

[1] Medical and Surgical History of the War of the Rebellion, Second Surgical Volume, p. 324.

because the volume of blood in circulation is rapidly diminishing, and at the same time the heart's action is growing weaker. The height and force of the jets are also greatly modified by the size, shape, and directness or indirectness of the aperture in the integuments and other parts external to the injured vessel. Thus, other things being equal, the jets are more strongly marked when the artery has been opened directly, and with free incision—by a sabre-cut, for instance—than when it has been indirectly pierced by a stab with a narrow-bladed knife. Again, the jets vary in accordance with the magnitude of the injured vessel itself, and the extent to which it has been laid open. So obviously true is this part of the description, that no illustrative example is needed.

(2) *Venous Hemorrhage.*—In venous hemorrhage, the blood has a dark-red or maroon color, and usually is found flowing in a dull, steady stream. But in veins which lie close to large arteries, the pulsatory movements of these vessels may be communicated to the contents of the veins, and thus when these veins are wounded, a throbbing motion may be discernible in the stream, which, however, can, with a little care, be readily distinguished from the "per saltum" of arterial hemorrhage. Again, in certain forms of cardiac disease, where the tricuspid valve does not completely close, the regurgitation consequent thereon may be attended by a peculiar pulsation in the jugular and other veins near the chest, synchronous with pulsation in the arteries; but this condition is easily recognized when attention is called to it. Furthermore, in gunshot fractures of the skull with lacerations of the dura mater, where the shot and trephine holes, and removal of the detached fragments of bone, had opened the cranial cavity extensively, I have several times seen the respiratory movements produce a notable rise and fall of blood in the cerebral veins and sinuses, synchronously with the respiratory movements themselves, the blood rising with the expiratory and falling with the inspiratory movement; and blood when settled into the bottom of these wounds, from venous and capillary oozings, was also observed to trickle away in correspondingly intermittent streams. But the suction-power which the chest exerts, through the movements of respiration, upon the great veins that enter it, acts much more strongly still on the contents of the contiguous veins, for example, the veins of the cervical, clavicular, and axillary regions; and hence venous hemorrhage in these regions may be attended with strong wave-like motions in the stream that correspond to the breathing. Hence, in these regions also, venous hemorrhages may be attended by the entrance of air into the wounded veins, it being, as it were, sucked into the open mouths of these veins by the inspiratory movements.

Venous hemorrhages, in general, are easily recognized, and give but little trouble. Occasionally, however, they spring from great vessels—for instance, the internal jugular, the axillary, the subclavian, the innominate, the azygos, the cavæ, the iliacs, and the common femoral vein—and then they may quickly destroy life. Examples of this will be adduced in the section on Wounds of Veins.

Varicose veins of the leg, thigh, rectum, etc., bleed when they burst, with a double force; for, being unprotected by valves, they possess a reflux or regurgitated current of blood, as well as a direct one, towards the aperture.

Hemorrhages from the almost valveless veins of the head and neck may be greatly increased by the struggles and cries of patients, especially when restraint is employed and the posture is recumbent.

Superficial lacerations of the liver bleed inordinately, because the hepatic veins, being not contractile and not surrounded with loose tissue, cannot close nor even collapse when divided, and their mouths are held open by the surrounding structures.

But in most cases where venous hemorrhage proves troublesome, it is because there is some undue pressure acting upon the veins above the seat of the hemorrhage, that is, between it and the heart. The loosening of the tourniquet stops bleeding from the veins of a stump. At the battle of Ball's Bluff, I saw a soldier having a shot flesh-wound of the left arm, who was much weakened and exsanguinated from a venous hemorrhage that was caused by applying an improvised tourniquet above the wound (it was done by a comrade), and was readily stopped on removing the cause. The late Drs. Neill and McClellan, of Philadelphia, were called one night to see a young man who had lost a "deluge" of blood in bed from return of the bleeding six hours after venesection, and found that the difficulty had proceeded from the tightly retracted sleeve of a woven undershirt, which had not been drawn down into place along with the shirt-sleeve after the venesection was over. On another occasion, McClellan "was called back to suppress a frightful venous hemorrhage," in a case where he had removed a very large tumor involving one of the breasts of an unmarried woman; and, on opening the dressings, found that the long strips of adhesive plaster, put on to maintain the apposition of the edges, had tightly compressed several large varicose cutaneous veins, above and in front of the wound, *i. e.*, on the cardiac side of it; "the moment the strips were removed, the hemorrhage ceased."[1]

Muscular contractions, whether voluntary or otherwise, favor the occurrence of venous hemorrhage in the limbs, because of the compression they exert on the wounded veins.

Venous hemorrhage may also be increased by placing the wounded part in a depending position, whereby the blood gravitates towards the hole in the vein. I have often noticed this fact in amputating the thigh. On lifting up the stump, the hemorrhage from the femoral vein generally ceases. On depressing it again the bleeding may return.

Often, when venous hemorrhage occurs in one of the great cavities, it may prove fatal not only by reason of the quantity of blood that is effused, but also because of its confinement in the cavity; for instance, when a ruptured sinus of the dura mater bleeds, death from compression of the brain not unfrequently follows.

(3) *Capillary Hemorrhage.*—In capillary hemorrhage, the blood discharged is not as bright-red as the arterial, nor yet is it as dark-red as the venous blood; and thus it has a peculiar color of its own. Moreover, it does not issue in distinguishable streams from the affected vessels or parts, but apparently oozes out of the bleeding surface. Capillary bleedings are generally small or moderate in extent; sometimes, however, they are so profuse as to endanger and even destroy life.

Capillary hemorrhages are often met with on the free surface of mucous membranes; for instance, on that which lines the nasal fossæ, the gums, the urethra, etc.

The capillaries when wounded, as a rule, do not bleed much, as already indicated. A single gush, or at most a few gushes occur from their open mouths, which are at once shut up by contraction of the muscular fibres in their walls, and then the bleeding is at an end.

Sometimes, however, the capillaries when wounded do not contract immediately, nor even speedily, and then they may discharge a great deal of blood before the flow can be arrested. I have seen this happen in amputations and other cutting operations performed in parts that were inflamed; and examples

[1] Principles and Practice of Surgery. By George McClellan, M.D., pp. 194–198.

of it will be presented in the section on Parenchymatous Hemorrhage. In operations performed by the bloodless method of Esmarch, tardiness of contraction on the part of the wounded capillaries may subsequently be attended with the loss of much blood.

Capillary hemorrhages in granulating wounds may be produced by excesses in drinking, and by indulgence in venery; I have seen examples of both accidents.

Capillary hemorrhages in granulating wounds too, are often caused by the formation of thrombi in the veins which should carry the blood away from these wounds; cases illustrating this point will also be adduced in the section on Parenchymatous Hemorrhage.

The chief factors concerned in producing the bleeding from capillaries which require surgical treatment, are: 1. Excessive blood-pressure in the arteries, whereby the capillaries themselves are burst open and the blood is forced out through minute rents in their walls: *e.g.*, the nasal hemorrhages often met with in Bright's disease, the hemorrhages from granulating surfaces which result from indulgence in venery and from excessive drinking, etc.; 2. Inability on the part of the capillaries themselves, when severed, to contract, and thus close their open mouths, in consequence of paralysis, more or less complete, of their walls; and 3. Obstruction to the onward flow of blood, which is not unfrequently caused by occlusion (plugging) with coagula or thrombi of the veins that should conduct the blood away from wounds and granulating surfaces: *e.g.*, parenchymatous hemorrhage occurring in pyæmia and other debilitating diseases which produce thrombosis.

But all the traumatic hemorrhages, those that are internal as well as those that are external, and those proceeding from wounded veins and capillaries as well as those proceeding from wounded arteries, are naturally separable into four distinct groups or classes, each of which, in practice, has great importance, viz.: (1). *Primary;* (2). *Intermediary;* (3). *Secondary;* and (4). *Parenchymatous* hemorrhage. Now, this classification of the traumatic hemorrhages, while quite unarbitrary, is still very useful for purposes of study and description; and this circumstance should commend it to general favor and acceptance.

(1) By *primary hemorrhage* is meant the effusion of blood which usually attends immediately upon the wounding of bloodvessels, that is, the hemorrhage which takes place at the moment the wound is inflicted. Its phenomena vary considerably according to whether it proceeds from veins, from arteries, or from capillaries; and when it proceeds from a wounded artery, the phenomena vary with the extent of the aperture in its walls, that is, according to whether the vessel is completely or only partially divided; they also vary with the nature of the wound of the artery itself, that is, according to whether it has been inflicted by a sharp, cutting instrument which would make an *incised* wound; or by a sharp-pointed instrument, like a narrow dagger, or a bayonet, which would cause a *punctured* wound; or whether the vessel has been torn across by stretching, so as to sustain a *lacerated* wound, such as sometimes results from a limb being caught in machinery; or whether the coats of the vessel have been bruised, thereby sustaining a *contused* wound; or, finally, whether the artery has been opened by a gunshot missile, which usually makes a wound both contused and lacerated, a *gunshot* wound. Primary hemorrhage is, therefore, a subject which must be considered in connection with the several kinds of injury, or wounds, to which the bloodvessels are exposed; and, in our description of these wounds, severally, a full discussion of this subject will be presented.

(2) By *intermediary hemorrhage* is meant an effusion of blood from wounded

vessels which presents itself during what is called the intermediary period in the natural history of wounds, that is, during the period that intervenes between the stage of depression from shock on the one hand, and the stage which is marked by the occurrence of suppuration on the other. Intermediary hemorrhages, therefore, come on with reaction from shock, before the apertures in wounded bloodvessels are securely closed, as well as before the appearance of purulent matter; either because the blood pressure is unduly increased by reaction, or because the external compression has ceased to be properly applied, the occluding coagula becoming thus displaced, and the blood flowing out afresh.

(3) By *secondary hemorrhage* is meant an effusion of blood from wounded vessels which does not occur until the establishment of suppuration, and the consequent separation of sloughs, eschars, etc., from the injured vessels. It does not appear before the fifth or sixth day after the infliction of a wound, and is most liable to happen about the twelfth or fourteenth day.

(4) By *parenchymatous hemorrhage* is meant a sanguineous effusion in which the blood does not issue from the wounded, granulating, or ulcerating surface, in distinct streams, but seems to be poured out therefrom by a process of general oozing through small apertures, that is, from the parenchyma or substance of the part.

Each of the three last varieties of traumatic hemorrhage will be thoroughly discussed by itself in a distinct section, after the wounds of arteries have been described.

Constitutional Signs of Hemorrhage.—By loss of blood or hemorrhage a strikingly changed appearance of the human body, sometimes called exsanguinated or bloodless, is produced. The countenance, ears, lips, buccal mucous membrane, conjunctivæ, and general integuments, become deathly pallid, and pinched or shrunken from departure of blood; the expression becomes languid or vacant, and the surface is wet with cold sweat, which may stand in drops. At the same time, the functions of the brain, from anæmia of its substance, are greatly disturbed: humming, roaring, or ringing sounds are heard in the ears; a thick mist, or even darkness, perhaps illuminated with flashes of strange light, comes before the eyes; the sense of feeling is benumbed; and unconsciousness, with syncope or convulsions, follows. There is also extreme debility, with a faint voice, feeble, sighing, or gasping respiration, and small, frequent, weak, fluttering, or even scarcely perceptible pulse. Such are the general symptoms which attend and characterize excessive loss of blood, whether it be poured out externally or into the great cavities of the trunk. There are, however, some considerable differences between the symptoms that appear in the slow and in the sudden hemorrhages. In the former, the patient is very slowly exhausted; at each return of bleeding he faints, and is laid in bed, and applications of cold, and the fainting itself, save his life. After some days, he rises, pale, languid, and giddy; his pulse flutters, and is hardly to be felt; his breathing is quick and anxious, accompanied with sighing and great oppression; his heart palpitates on the slightest exertion; and the slightest inclination of his head, or rising suddenly from the couch, endangers fainting. His voice is low; his eye is languid, colorless, and of a pearly white; his flesh feels soft and woolly, and his skin is pale and yellowish, gelatinous, and, as it were, translucent, like modelled wax. After this stage of weakness, the blood loses its color; from this time forward it is a bloody serum only that distils from the vessels; dropsy appears; and the slightest loss of blood proves fatal. (John Bell.)

But, when the patient dies suddenly by an impetuous hemorrhage from

some great artery; when he succumbs to the bleeding from a femoral aneurism; when he is wounded in the chest or abdomen, and some large vessel is pouring out a great stream, the blood circulating at large, in place of being forced onward by the contractions of the arteries, runs backward toward the hole in the wounded artery from all parts of the body. The arteries no longer push forward the contents of the veins; the blood ceases to flow toward the heart; the heart itself ceases to act; and the countenance assumes, as in asphyxia, a livid tinge from the stagnation of venous blood. The face becomes, all at once, deadly pale, the circle round the eyes is livid, the lips are black, and the extremities are cold. The patient faints, revives, and faints again, with a low and quivering pulse; he has nausea, and his voice disappears. There is an anxious and incessant tossing of the arms, with restlessness, which is the most fatal sign of all. He tosses continually from side to side; his head falls down in the bed; at times he suddenly raises his head, gasping for breath, with inexpressible anxiety; the tossing of the limbs continues; he draws long, convulsive sighs; the pulse flutters and intermits with the breathing, more and more, and he expires. The countenance has not the translucent pallor which is mentioned above, but the clayey and leaden hue which painters represent in those who are assassinated or killed in battle. (John Bell.) I can further unite with this graphic writer in stating, from my own personal observation, that the incessant tossing of the limbs, which is commonly represented as the sign of a fatal wound, is, indeed, so infallible a sign of death that I have never known any one to recover from hemorrhage who exhibited this condition of indescribable restlessness.

But some of the symptoms require additional mention. During syncope from hemorrhage, the act of breathing is very feeble, and performed by the diaphragm alone. After syncope, an attack of vomiting often attends the return of consciousness. At the same time, as the heart resumes its functions, contracting feebly at first, but afterwards with frequency and occasionally even with violence, the pulse becomes quick, jerking, soft, and easily compressible, the tube of the artery itself being large, not tense, and contracting very imperfectly after each small wave of blood has shot through it, thus constituting the so-called *hemorrhagic pulse*. If, instead of bounding and jerking and thrilling, the pulse is feeble and soft, perhaps barely perceptible, after reaction from syncope, it is almost certain that further loss of blood can be prevented by moderate measures.

*Hemorrhagic Fever.*—After great losses of blood, a condition of body characterized by a tendency to febrile movement, with great irritability of the heart and arteries, is apt to set in. It is so-called "irritative fever," combined with anæmia. The quantity of blood in the system being but small, the heart and arteries make violent efforts to supply the deficiency by hurrying what blood there is forward. Hemorrhagic fever, so-called, is marked by the symptoms of great loss of blood, alternating with periods of vascular excitement, the pulse becoming much hurried, fluttering, jerking, and irregular in force and frequency; slight flushings of the face with brilliancy of the eyes appear, rapidly passing again into pallor and syncope; and if, at last, the hemorrhage prove fatal, delirium and convulsions, with extreme restlessness, usually precede the end. (Erichsen.) The symptoms which attend hemorragic fever are those of high or inordinate excitation without strength; they ought never to be mistaken for those of inflammation, for they are not attended with increment of the body-heat. Wandering of the mind, or *delirium*, is often present in cases of so-called hemorrhagic fever. It is never violent, but generally of a low muttering character, and is best treated by administering nutrients and stimulants.

*Hemorrhagic Convulsions.*—Animals that are bled to death usually exhibit bilateral spasms; so, too, in man, epileptiform convulsions are a direct consequence of sudden and copious loss of blood. Some persons are, by nature, much more strongly predisposed to the occurrence of convulsions from loss of blood than others; hence it happens that, in occasional instances, severe convulsions are caused by comparatively small losses of blood. These spasms, called by some *convulsio syncopalis*, are compared by many to those of epilepsy, and are generally considered to be epileptiform in character. The pulse at the wrist may continue deficient or barely perceptible throughout the fit, or it may return long before the close. Hemorrhagic convulsions are not of necessity fatal; generally they are not dangerous; and, for the most part, they yield to the same treatment as ordinary syncope. Great care, however, should always be taken to keep the patient's head in a depressed position as long as they continue. The only fatal cases which I find mentioned by practitioners were of patients improperly treated by further depletion, or who were unwisely raised up into erect postures of body, whereupon syncope, without reaction, ensued.

Great losses of blood also cause a pinched appearance of the face and a shrunken condition of the whole body, for the size of the organism is absolutely lessened by the amount of the blood abstracted from it; and the loss in bulk at the same time falls most heavily, or indeed almost entirely, on the soft parts exterior to the framework of the body. The pinched and exsanguinated appearance which the *cadaver* presents, in cases of death from hemorrhage, cannot be produced from any other known cause.

The constitutional phenomena of hemorrhage, when it is excessive, are very strongly marked, and of themselves are quite sufficient to enable us to diagnosticate that condition with certainty, even in cases where the extravasation is wholly internal—for example, in the abdominal or thoracic cavity—and where no trace of blood appears on the exterior of the body.

Some persons support the loss of blood much better than others. One adult may swoon on the abstraction of twenty ounces, another will bear the loss of more than forty ounces without swooning. Young and vigorous men may lose a great quantity of blood, and yet rally. Children bear the loss of blood badly, yet they rally quickly. In old age a slight hemorrhage is often of great importance, because the ability to rally is but small. Death from hemorrhage may occur suddenly upon the patient's assuming or being placed in an erect posture, or upon raising up his head, or upon allowing his arms or legs to fall down from the couch; hence all such changes are to be reprobated. Finally, there are fatal instances of hemorrhage in which death is due not so much to the quantity of blood that is lost, as to the association of terror, or of pre-existing disease, or to the influence of a suicidal purpose.

After sudden and exhausting hemorrhages, especially those which are about to prove fatal unless transfusion be promptly employed, the injured arteries are sometimes seen lying in the wounds collapsed, and without exhibiting any signs of pulsation. It is because the waves of blood have not sufficient momentum imparted to them by the heart to reach the severed arteries. During the late war I several times noted this pulseless condition of wounded arteries after great losses of blood, and now, in looking back, I have no doubt that some of these cases might have been saved by the operation of transfusion, if it could have been seasonably performed.

## Spontaneous Arrest of Arterial Hemorrhage.

This point of doctrine has much practical importance, and therefore should be discussed in all its details. For Nature to durably stop the bleeding from wounded arteries, it is primarily requisite that the arteries themselves should be completely divided by the accident or the operation. When we closely scan the faces of large wounds, such, for instance, as are made in cutting off limbs, after the first sudden gush of blood is over, we see but little if any flow of blood, except that which comes forth in distinct and plainly visible streams; thus it is evident that the mouths of almost all the multitude of minute vessels shown in well-injected preparations of the tissues, become closed immediately after the vessels themselves are divided. The contact of the amputating knife, supplemented by that of the air, and of cold, induces the muscular fibres at the exposed ends of these vessels to contract so much as to close the small ones completely, and to lessen the size of all considerably. Whatever hinders this contraction of the vessels prolongs and increases the bleeding. Hence large bleedings sometimes issue from the comparatively small vessels that pass through or are connected with firm and close structures, as, for instance, the small arteries in or near the aponeuroses and fasciæ, or in the compact portions of the skin, *e. g.*, that of the face, etc. So, too, in parts which are inflamed, or adjoin the seat of active disease, the dilated vessels bleed largely and long when divided, because of the loss of contractile power in their muscular coats.

Gradually, with or without surgical aid, all the vessels divided in an operation, or accidental wound, become closed and cease to bleed; very frequently also the larger arteries are helped to this end considerably by the retraction of their extremities into the inter-muscular connective tissue, and still more by the formation of coagula within and over their constricted orifices, and by the diminished force of the cardiac contractions and blood-pressure which results from prolongation of the hemorrhage. Coincidently, the flowing blood becomes gradually brighter and paler. And, if the wound be left open, after pure blood has ceased to flow, there is an oozing of blood-tinged, serous-looking fluid; and this is gradually succeeded by a paler fluid, some of which collects, like a whitish film or glazing, on the surface of the wound. It contains very numerous white blood-corpuscles, imbedded, apparently, in a fibrinous film. (Paget.)

The spontaneous arrest of hemorrhage from divided arteries is brought to pass by the coincident operation of several distinct agencies, which are the following:—

I. Contraction of the Artery.—*Contraction* of the artery at the place of division ensues, the consequence being that the orifice is either closed completely, an occurrence which generally comes to pass when small arteries are severed; or that the orifice is closed in part, that is, constricted, a result which not unfrequently is attained when large arteries are divided. This closure or constriction of the bleeding orifice, which almost uniformly attends the complete division of small arteries in wounds, is due to contraction of the muscular and elastic fibres belonging to the several coats of the artery which circle immediately round the orifice, under the stimulus of the wound itself, or of the atmospheric air, or of the external cold to which it is exposed. Moreover, the surgeon is not unfrequently called on to assist Nature in stopping arterial hemorrhage by opening and clearing out the wound so as to lay the bleeding apertures completely bare to the action of fresh cool air, cold water,

ice, etc., whereby full contraction of these muscular fibres and consequent closure of the bleeding apertures may at once be obtained.

II. Retraction of the Artery.—*Retraction* of the ends of the severed artery into its sheath, and into the loose connective tissue by which arteries and their sheaths are not unfrequently surrounded, likewise ensues. But it does not follow the complete division of arteries with anything like the same uniformity as contraction of the cut extremities. It is often inconsiderable, and sometimes even does not take place. For instance, I have seen in a wound of the palm of the hand where a branch of the radial artery was divided, the two ends of the injured vessel not retracting, but, in fact, projecting somewhat from the surface, so as to be easily taken up and tied. I have also seen very nearly the same thing occur in wounds of the scalp, and in wounds of the face. But when the severed artery is not surrounded by dense structures, when it is situated between the muscles and not in the substance of any of them, and the connective tissue around it is quite lax, then the two ends retract very sensibly, and become buried, as it were, in the flesh. When retraction such as this occurs, it renders the escape of blood much more difficult, and thus assists materially in suppressing hemorrhage. The retraction of severed arteries is also due solely to the action of the muscular and elastic tissue in the several coats; and, generally, it does not take place as early or as promptly as the constriction of the cut extremities.

III. Coagulation of the Blood.—When the orifices are not completely closed by contraction of the muscular coat, the blood may *coagulate* as it escapes from these orifices, and thus fill the part of the wound external to the cut ends of the artery with a firm clot called the *external coagulum;* and, likewise, may fill up or plug the constricted ends of the artery with a firm clot called the *internal coagulum.* Thus arterial bleeding may be, and not unfrequently has been, completely suppressed; and when the internal coagulum becomes organized, the bleeding remains permanently arrested, and the arterial canal at the place of injury becomes obliterated.

IV. Increased Coagulability of the Blood.—As the hemorrhage progresses and syncope approaches, the tendency of the blood to coagulate is very much augmented; and this acquired quality of the blood often assists not a little in the process of natural hæmostasis.

V. Diminished Force of the Heart.—Diminution of the force with which the heart contracts, as the loss of blood increases, also facilitates very much the occurrence of natural hæmostasis. The vigorous manner in which the jet of blood is thrown by each contraction of the left ventricle, is the principal obstacle to the formation of blood-clot around and within the cut vessel; for not only does the movement of the blood prevent coagulation, but, as long as the jet is more powerful than the cohesion of the clot, it will certainly wash the coagulum away. As the blood flows, and the heart's impulse becomes gradually lessened in force, the jet becomes lower and lower, until at last, when faintness comes on, it is almost entirely arrested, and time is afforded to form and consolidate a coagulum which shall permanently close the aperture in the wounded artery.

Phenomena of Spontaneous Arrest of Arterial Bleeding.—The spontaneous arrest of hemorrhage from such arteries as the radial and ulnar, when wounded, is attended with the following phenomena:—

"In many cases of amputation at the wrist and forearm," says Guthrie, "in which I wished the patient to lose a certain quantity of blood, I have allowed either the radial or ulnar artery to bleed until it ceased. At first, the jet appears interrupted, then the stream becomes continuous, although projected further at each systole of the heart. As the orifice contracts, the flow of blood becomes more equal, it is thrown to a less distance, the size of the stream is smaller, and it goes on diminishing until it only oozes out, and then soon ceases; the extremity of the vessel being covered by a layer of coagulum of greater or less thickness. The experiment may be made every day upon the temporal artery, with this addition, that as the stream diminishes let a fillip with the nail be given to the extremity of the vessel, when the jet will become a little larger; and this may be done several times, until at last it fails to have any effect, and the hemorrhage ceases. In none of these instances could the retraction of the artery be fairly estimated, although it appears from analogy, and from what is seen to occur in other cases, that a certain degree of it must have taken place. In similar cases, in which I have been able to make an examination either after death or amputation, the contraction [but not the retraction] of the vessel was evident, as well as the formation of a very slight external coagulum, extending into the canal of the artery. The sheath of the artery could do nothing, because there was none; neither did the internal coagulum, which, at this period, strictly speaking, does not exist. In small vessels, such as the radial or ulnar arteries, I do not believe anything depends on the diminished power of the circulation; but when the axillary and femoral arteries are divided, the shock of the injury and the loss of blood powerfully contribute to the suppression of hemorrhage."[1]

Guthrie's observations concerning the absence of retraction in such arteries as the radial and ulnar in the lower third of the forearm, together with the anterior temporal and facial, etc., when divided in wounds, agree pretty closely with what I have seen. But when large arteries that are invested with sheaths, and are likewise imbedded in loose connective tissue, for instance, the brachial, axillary, femoral, etc., are divided completely in shot-wounds, and they cease to bleed spontaneously, which sometimes happens, and several examples whereof will hereafter be presented, the retraction of the ends becomes quite strongly marked and noteworthy. Of such cases Dr. Jones has furnished an excellent description:—

An impetuous flow of blood, a sudden and forcible retraction of the artery within its sheath, and a slight contraction of its extremity, are the immediate and almost simultaneous effects of its division. The natural impulse, however, with which the blood is driven on, in some measure counteracts the retraction, and resists the contraction of the artery. The blood is effused into the cellular substance between the artery and its sheath, and, passing through that canal of the sheath which has been formed by the retraction of the artery, flows freely externally, or is extravasated into the surrounding cellular membrane, in proportion to the open or confined state of the external wound. The retracting artery leaves the internal surface of the sheath uneven, by stretching or lacerating the cellular fibres that connected them. These fibres entangle the blood as it flows, and thus the foundation is laid for the formation of a coagulum at the mouth of the artery, which appears to be completed by the blood as it passes through this canal of the sheath, gradually adhering and coagulating around its internal surface till it completely fills it up from the circumference to the centre.

A certain degree of obstruction to the hemorrhage, which results from the effusion of blood into the surrounding cellular membrane, and between the artery and its sheath—but particularly the diminished force and velocity of the circulation, occasioned by the hemorrhage, and the speedy coagulation of the blood which is a well-known consequence of such diminished action of the vascular system—most essentially contribute to the accomplishment of this important and desirable effect.

A coagulum, then, formed at the mouth of the artery, and within its sheath, and

[1] Diseases and Injuries of Arteries, pp. 225, 226.

which I have distinguished in the experiments by the name of the *external coagulum*, presents the first complete barrier to the effusion of blood. This coagulum, viewed externally, appears like a continuation of the artery; its termination can be distinctly seen with the coagulum completely shutting up its mouth, and inclosed in its sheath.

The mouth of the artery being no longer pervious, nor a collateral branch very near it, the blood just within it is at rest, coagulates, and forms, in general, a slender conical coagulum, which neither fills up the canal of the artery nor adheres to its sides, except by a small portion of the circumference of its base, which lies near the extremity of the vessel. This coagulum is distinct from the former, and I have called it the *internal coagulum*.

In the mean time the cut extremity of the artery inflames, and the vasa vasorum pour out lymph, which is prevented frcm escaping by the external coagulum. This lymph fills up the extremity of the artery, is situated between the internal and external coagula of blood, is somewhat intermingled with them, or adheres to them, and is firmly united all round to the internal coat of the artery.

The permanent suppression of the hemorrhage chiefly depends on this coagulum of lymph; but while it is forming within, the extremity of the artery is further secured by a gradual contraction which it undergoes, and by an effusion of lymph between its tunics and into the cellular membrane surrounding it; in consequence of which these parts become thickened, and so completely incorporated with each other, that it is impossible to distinguish one from the other; thus, not only is the canal of the artery obliterated, but its extremity also is completely effaced, and blended with the surrounding parts.

When the wound in the integuments is not healed by the first intention, coagulating lymph, which is soon effused, not only attaches the artery firmly to the subjacent and lateral parts, but also gives it a new covering, and completely excludes it from the external wound, which then goes on to fill up and heal in the usual manner.

The circumstances now described are observed also in the inferior portion of the artery, or that which is supplied with blood by anastomosis; with this difference only, that its orifice is generally more contracted, and the external coagulum is much smaller than the one which adheres to the mouth of the superior portion of the artery, or that from which the blood flows in its direct course from the heart.

From this view of the subject we can no longer consider the suppression of hemorrhage as a simple or mere mechanical effect, but as a process performed by the concurrent and successive operations of many causes; these may briefly be stated to consist in the retraction and contraction of the artery; the formation of a coagulum at its mouth; the inflammation and consolidation of its extremity by an effusion of coagulable lymph within its canal, between its tunics, and in the cellular substance surrounding it.[1]

When the arm is torn off at the shoulder, the bleeding often is but slight, and ceases spontaneously, because the internal and middle coats of the arteries are broken off short, while the external coat and sheath are dragged down and twisted over the torn ends of the arteries in such a way as to afford a ready lodgment for an occluding coagulum or plug, whereby the further outflow of blood is prevented. In such cases the arteries may be seen hanging out of the wounds, and pulsating down to their very ends, which are usually contracted to mere points, the hemorrhage, at the same time, being completely suppressed. In such cases it may also be observed, that with every pulsation the end of the torn artery is thrust downwards, but that it recoils again during the intervals between the pulsations. This fact proves that arteries are endowed with extensibility and elasticity, as well as with contractility and retractility. The details of this subject given above, although numerous, are drawn wholly from the experience of competent observers, and their presentation has been deemed necessary for a correct understanding of the different ways in which Nature suppresses hemorrhage from arteries both small and large.

It is not difficult to understand why hemorrhage is much more apt to cease

[1] On Hemorrhage, pp. 53 *et seq.* London, 1805.

spontaneously when arteries are completely, than when but partially divided. In the latter case the injured part of the artery cannot contract in such a way as to lessen the size of the aperture; but, on the contrary, the contraction of the muscular and elastic fibres involved generally causes the aperture to gape open, and thus when an artery is but partially divided, the bleeding orifice is usually enlarged instead of being lessened by the arterial contractility; and the flow of blood therefore is promoted rather than lessened thereby. Again, when partial division takes place, the injured part of the artery cannot be withdrawn or retracted into the sheath, and thus the external coagulum, when formed, is much less likely to have a foothold which will secure it from ejection when the pulse rises after the depression of syncope passes away. Furthermore, when an artery is but partially divided, the formation of an internal coagulum, spontaneously, is impossible. The continuity of the vessel being still preserved in greater or less degree, in inverse proportion to the extent to which the division has been carried, the current of blood in the canal is not retarded or stagnated sufficiently for coagulation to occur. It continues to flow through or past the opening made by the wound in a wave-like stream; and any small clots which might form would be swept away in the current. Hence, too, it sometimes happens that when small arteries, such as the radial, ulnar, and temporal, are partially divided in accidents or attempts at self-destruction, the resulting hemorrhage proves fatal unless stopped by art.

In discussing the spontaneous arrest of hemorrhages, it should also be mentioned that the parts external to the wounded artery sometimes furnish valuable assistance to this end. If, for instance, the opening through them be valvular, they may afford an excellent support to the external coagulum. If the track of the wound be narrow and ragged, as well as oblique, a backing to the external coagulum that is still better will be furnished.

When wounded arteries are plugged by foreign bodies, such as bullets, pieces of equipment, clothing, etc., the primary bleeding is sometimes thoroughly restrained thereby, as happened in the following instance:—

At the Washington Infirmary, August 15, 1861, through the courtesy of Dr. J. W. S. Gouley, I had the opportunity of examining a very instructive preparation of the left common carotid artery and contiguous parts, obtained on the previous day at the autopsy of a soldier who had died of secondary hemorrhage from a gunshot wound of the left side of the face and neck, received fourteen days before the hemorrhage occurred.

The missile was the old or round musket-ball; it struck the lower jaw, well forward, when nearly spent, and was deflected downward, backward, and slightly outward, in such a way as to pass obliquely through the left common carotid artery, and to lodge in the tunics and sheath of that vessel underneath the omo-hyoid muscle, pressing somewhat upon the par vagum, and occluding completely the proximal end of the divided artery. The hemorrhage came on suddenly and without any premonition, two or three days after entering the hospital, and fourteen days after the casualty. The bleeding was very profuse; the patient lost more than a quart of blood, which flowed in a great stream from his mouth. An attempt to tie the common carotid above the omo-hyoid muscle was made, but it had to be abandoned on account of the great profuseness with which blood flowed into the wound of operation, rendering a continuance of the search for the wounded artery impossible. It was believed by all the surgeons present that the patient was now so much exhausted from loss of blood as to make it useless to attempt to tie the common carotid artery below the omo-hyoid muscle; and death followed the next morning. Moreover, the source of the hemorrhage was not suspected, until the autopsy revealed it. The autopsy showed, among other things, that the dissevered common carotid artery was still occluded, on the side of the wound toward the heart, by the impacted ball; that a false aneurism as large as a filbert and elongated in shape had been formed at the distal extremity and on the inner side of the

dissevered artery, just above the omo-hyoid muscle; that the hemorrhage occurred from rupture or spontaneous opening of the sac of this traumatic aneurism; that the hemorrhage was not direct, but regurgitant in character, inasmuch as the escaping blood flowed backward, that is, toward the heart, through the distal portion of the artery; and that the hemorrhage could not have been arrested without tying it on the distal side of the wound. The ligation of the common carotid below the omo-hyoid muscle would, therefore, not have done any good, unless the vessel had at the same time been tied above or on the distal side of the wound and aneurism. The aneurism itself constituted a remarkable, and, as far as I know, a unique feature of this case, because it was developed from the distal end of the artery; and its occurrence can only be explained on the assumption that the communication between the carotids and vertebrals through the circle of Willis was unusually free.

Another case in which bleeding from an artery torn by gunshot was prevented by the bullet, has been reported by Dr. Dewitt C. Peters, U. S. Army.[1] The right vertebral artery was extensively lacerated at the point where it passed through the foramen of the transverse process of the atlas; the ball resting there probably acted as a plug, and thus restrained hemorrhage.

## General Considerations Concerning the Treatment of Surgical Hemorrrhage.

When the wounded vessel is superficial, that is, near the surface of the body, it is generally easy to determine that the blood issues from an artery rather than from a vein, by calling to mind the relative anatomy of the part, by actual inspection of the bleeding orifices, and by observing that the blood is bright-red and flows *per saltum*, instead of flowing in a continuous, dark-red stream. But, when the blood issues from deep-seated vessels whose positions correspond to both arteries and veins of considerable magnitude, it is not always so easy in practice, to determine from what vessels it proceeds. The admixture of arterial blood which must always flow to greater or less extent into the track of the wounds leading down to deeply-seated veins, may suffice to tinge the effusion with a brighter hue than that which belongs to venous blood; while on the other hand, the blood issuing from wounded arteries may rise to the surface mingled with much venous blood, and correspondingly darkened in color thereby. There are, too, various obstructions which often prevent, in deep wounds, the issue of blood from arteries in jets, synchronous with their pulsations; and when anæsthetics are freely administered, but especially when their administration is continued for considerable time, the color of the blood becomes greatly changed, so that in many instances the arterial cannot be distinguished by this test alone from the venous blood. Moreover, the blood which flows from the distal orifice in a severed artery is, for the most part, much darker than that which flows from the proximal orifice; and it often issues in a continuous stream from the distal orifice like that which flows from a wounded vein.

In some cases, therefore, we cannot at the first glance determine the source of the bleeding. In such cases valuable aid may sometimes be derived from compressing the main artery firmly on the cardiac side of the wound. If the hemorrhage be arrested by this procedure, it is certain that the bleeding is arterial; but if the hemorrhage be increased by this procedure, it is equally certain that a wounded vein is the principal source of the bleeding. Sometimes, however, from the presence of inflammation, or from want of room, or from some other cause, it happens that the main artery cannot be successfully

[1] American Journal of the Medical Sciences, April, 1865, pp. 373, 374.

compressed on the cardiac side of the wound. In such cases valuable or even decisive information may be obtained by exploring the wound with a finger; for thus the surgeon can feel the blood issuing in jets when it proceeds from the open mouth of an artery.

As already stated, I am convinced from my own observations, that a very large proportion of the persons killed in battle perish directly from loss of blood. On March 25, 1865, I examined the bodies of *forty-three* Confederate soldiers, killed in the assault on Fort Steadman, on the ground where they had fallen, in the lines before Petersburg. *Twenty-three* of them had been shot in the head; *fifteen*, in the chest; and *five*, in the abdomen. The blanched and exsanguinated appearance of the cadaver in the case of every one wounded in the abdomen, showed clearly that death had been caused by hemorrhage; and the extreme rapidity with which the result had followed the wound implied that some large bloodvessel had been opened. In the cases of all but two or three of those wounded in the chest, the body presented the peculiarly blanched appearance belonging to death from loss of blood. There was much blood in the clothing and on the ground where these men had fallen, in most instances where the trunk was wounded, and in some where the head was wounded. This circumstance shows that the hemorrhage was often external as well as internal. It is not improbable that in some cases where the cadaver did not present a blanched appearance, death was indirectly caused by traumatic extravasation of blood into the cavity of the chest, or that of the cranium, whereby the brain or the lungs sustained a compression which soon proved fatal. On June 8, 1862, Private Wallace Fairchild, Co. K, 106th Pa. Vols., was wounded in a skirmish at the rifle-pits near Fair Oaks, Va., by a sabre-bayonet, in the left thigh, the femoral artery being divided; this soldier bled to death before surgical attendance could be had. On the next day, June 9, Private Charles Riley, Co. G, 71st Pa. Vols., was shot through the neck by a musket or rifle ball, while on picket-duty near Fair Oaks, Va., and died of hemorrhage in a few minutes. Both cases were reported under the head of "killed," as death occurred on the field very soon after the mishap, and before removal could be effected.

My own experience in this regard does not differ much from that of others. Major Richard Lanning, 80th Ohio Vols., received at Corinth, October 3, 1862, a gunshot wound. The missile passed through his neck, just in front of the carotid artery. He died on the field, from hemorrhage.[1] The late Dr. Otis personally made "an aggregate of seventy-six observations of the bodies of the slain, on the field" of battle. The mortal wound was in the head in *twenty-seven;* in the neck in *four;* in the chest in *thirty-two;* in the abdomen in *nine;* and in the thigh in *four* instances. In the New Zealand War of 1863–5, of one hundred and eighteen men who were killed in battle, *forty* were wounded in the head; *four* in the neck; *fifty-nine* in the chest; *eleven* in the abdomen; and *four* in the thigh.[2] Guthrie states that General Sir Edward Packenham received a wound directly through the common iliac artery, at New Orleans, which killed him on the spot, and that Colonel Duckworth, of the 48th Regiment, received a ball through the edge of his leathern stock, at Albuhera, which divided the carotid artery, and killed him almost instantaneously. I am, therefore, led by the observations of others, as well as by my own experience, to believe that a very large proportion, probably one-half, of those slain in battle, die either directly or indirectly from hemorrhage.

Now, an inquiry of much practical moment suggests itself, viz.: What

[1] Medical and Surgical History of the War of the Rebellion. First Surgical Volume, p. 411.
[2] Ibid., p. 603.

efforts should be made to arrest the hemorrhage in desperate cases, such as those just mentioned? On this point the following examples will shed some useful light:—

At San Antonio, Texas, in the month of August, 1865 (as Dr. Sanford B. Hunt, late Surgeon U. S. Volunteers, informs me), Lieutenant Van Giesen, of the 18th N. Y. Cavalry, was accidentally wounded by a pistol in the hands of a comrade. The muzzle of the pistol was not more than three feet from the point where the ball entered, which was on the right side of the neck, immediately opposite the superior border of the thyroid cartilage, and directly over the origin of the external carotid artery. The point where the ball escaped was on the posterior part of the neck. The hemorrhage was great, being sufficient to render the injured man very pallid and faint, but was promptly checked by an intelligent bystander by compression effected with the thumb applied in the wound. The first surgeon to reach the case was Dr. Settle, formerly Medical Director of the Confederate Army in Texas. On withdrawing the compression, as Dr. Settle informed Dr. Hunt, the hemorrhage was renewed, a stream of blood as large as a crow-quill being thrown through the centre of a partially-formed clot to a distance of more than two feet, *per saltum*. It must have been over an hour after the wound was inflicted when I saw him (says Dr. Hunt). On again withdrawing the compression, no hemorrhage occurred. It was then ten o'clock P. M.; the patient lay on the ground out of doors; good light could not be procured, and it was decided to defer the operation. An assistant surgeon was left with the patient, the instruments, etc., were put in readiness, and I expected to ligate the common carotid next morning, or perhaps during the night.

Next morning, however, the clot was firm, no hemorrhage occurred, and the policy of delay was adopted. About the eighth day the clot softened, and came away without hemorrhage; the wound rapidly healed with hardly any perceptible suppuration (the ball had passed out posteriorly), and complete recovery resulted without operative procedure. After recovery there was no pulsation in the temporal artery of that side, and some coldness and numbness of the face existed for a time.

Again, in the summer of 1864, in front of Petersburg, an officer belonging to the Army of the Potomac (I think that the officer was Assistant Surgeon R. S. Vickery, 2d Michigan Volunteers) was wounded by a rifle-ball which divided the femoral artery in the upper part of its course; the hemorrhage was very profuse; but he had the presence of mind to compress the wounded vessel with his own fingers, and thus stay the bleeding, until he could be taken to a surgeon, who applied ligatures. This officer made a good recovery.

Furthermore, Dr. T. F. Azpell, U. S. Army, related to me a case in point which came under his own observation during the war of the Rebellion; the axillary artery of a soldier was wounded near its origin by a rifle-ball; the hemorrhage, which was very abundant, was arrested immediately by digital pressure, and was thus restrained until a ligature could be applied to the subclavian artery; this patient, too, got well.

In addition to the above cases may be mentioned that reported by the elder Larrey, of General Arrighi, Duke of Padua, who was struck in the neck by a musket-ball at St. Jean d'Acre. It wounded his right carotid artery, the hemorrhage was very profuse, and he must have died from it on the spot, if a soldier had not had the presence of mind to stop the bleeding by introducing his two forefingers into the wound, and keeping them there until Larrey arrived, who tied the wounded artery with a good result.

Digital compression, then, if brought to bear by introducing the fingers or thumb into the wound, and applying them directly to the bleeding orifices of artery or vein, may not unfrequently be employed with success to stay the hemorrhage until ligatures can be applied, in wounds of the neck, armpit, groin, extremities, etc., which otherwise would soon prove fatal from loss of blood. And digital compression may sometimes be applied in this way by the patient himself, as well as by a comrade or bystander; for the amount of pressure required to stop the bleeding from even a large artery is surprisingly small, when it is placed directly and held steadily upon the orifice itself of the wounded vessel. A knowledge of these facts should be widely

disseminated among the laity as well as the profession, for no consequences but good ones can result therefrom. Under any circumstances, efforts should be promptly and perseveringly made, whenever practicable, to stay the hemorrhage in all desperate cases by compressing the opened artery or vein with fingers in the wound, according to the method shown above, until surgical attendance can be obtained and ligatures properly applied. Had such a course been adopted in the cases of Privates Fairchild and Riley, mentioned above, and in several others of which I have personal knowledge, it is not too much to say that their lives might have been saved.

Gunshot wounds of any region of the body do not, in general, bleed as freely as incised wounds of the same region, that are similar in depth and extent. This difference is occasioned by the fact that the former are, for the most part, contused and lacerated in their nature. It is well known that when bloodvessels are severed by either a contusing or a lacerating force, the disposition to hemorrhage is considerably lessened by the form of the injury. When limbs are torn off by machinery, or crushed off by railway carriages, or carried away by cannon-balls, the loss of blood is not always so great as to prove fatal. In such cases the bleeding, which at first is very profuse, often ceases with the occurrence of syncope, and afterward does not recur to any considerable extent. If we examine the bruised and torn stump of a limb which has just been severed by a cannon-ball, we find that the smaller arteries give issue to but little if any blood, because their extremities are more or less completely closed by being blended with the crushed mass of muscular and connective tissue in the first place, and by the natural contraction of their muscular and elastic tissues in the second place. The main arteries in such cases may sometimes be seen hanging out of the ragged stumps, and pulsating down to their ends, which, however, are closed more or less completely by their contraction, and, generally, by the presence also of plugs of coagulated blood within the constricted orifices, which may perfect their occlusion. But the completeness of their closure accords in many instances with the lapse of time after the injury, being found to be more thorough after a considerable than after a brief interval. Thus we perceive that cases of contused, or of lacerated, or of gunshot wounds of arteries, may sometimes admit of delay in respect to surgical treatment, which would be wholly inadmissible in cases of incised wounds of the same arteries.

When wounds have been properly dressed, especially those that implicate large bloodvessels—for instance, wounds of the armpit involving the axillary artery or vein, wounds of the neck compromising the carotids or the internal jugular, wounds of the groin involving the common femoral artery or vein, etc.—much wariness should be exercised in regard to disturbing the dressings, unless there be a return of the bleeding; and even then, preparations should be made beforehand, and everything should be got ready to meet any possible emergency in the shape of hemorrhage bursting forth from the wound as soon as the bandage and compresses are taken off. Nothing can be more reprehensible than to disturb, from mere inquisitiveness, the dressings of a wound in which a great hemorrhage has just been arrested. As long as the parts are dry and quiet, they should generally be let alone until the normal discharges begin to loosen the dressings. By that time the processes of adhesion may have permanently closed the orifice in the wounded artery or vein, and thus all secondary bleeding may be prevented.

During the riots in Southwark (says McClellan), I dressed a horrid cannon-shot wound in the right groin of a young soldier from Germantown. He had been struck there by a broken piece of cast iron, with the fragments of which one of the cannon in the hands of the mob had been loaded. The whole fore-part of the fleshy substance of

the groin, in contact with Poupart's ligament, had been torn away, and a prodigious rent made across the artery, with a hole in the vein. He had flooded the floor, on which he lay, with gore, and was deadly faint when I arrived. It was late at night, and the rioters were all around. I, therefore, applied graduated compresses, and bound them down with a spica bandage. But it required two hours' constant nursing, with his head and shoulders in my lap below the bedside, and the incessant use of cordials and brandy, to revive him. During his reaction the poor fellow was delirious, and wanted to go home. He had no return of hemorrhage, however, and by morning I got him so far recovered as to have him transported in a carriage to one of the hospitals. There, however, somebody stripped off his bandage and pulled away the compresses, to see how I had dressed the wound. The blood gushed out in a torrent, and a second fainting process carried off the patient.[1]

But, although the primary dressings should never be disturbed from motives of idle curiosity, especially in cases where the patient has already been brought low by hemorrhage, still instances not unfrequently occur where it is the bounden duty of the surgeon to re-open the wounds as soon as practicable, and secure by ligatures, or by other effectual means, the open mouths of the wounded vessels; for instance, when the femoral artery is punctured by a penknife-blade, and blood is being more or less widely extravasated in the loose connective tissue between the muscles of the thigh; or the internal epigastric artery has been opened by a penetrating wound of the belly, and blood is flowing internally into the abdominal cavity; or the intercostal or internal mammary arteries are wounded, and blood is pouring therefrom into the pleural cavities—the dressings should be removed without delay, and well-directed efforts should be persistently made to stop the internal bleeding. To the femoral and internal epigastric arteries, ligatures should be applied on each side of the bleeding orifice. The intercostal and internal mammary arteries should also be tied if possible; but, in case of failure to ligate them, the bleeding should be stopped by Desault's pad or tampon, the preparation and application of which will shortly be described.

Chemico-Vital Treatment of Surgical Hemorrhage.—The chemico-vital agents which may be employed for the suppression of hemorrhages are very numerous, and are denominated chemico-vital hæmostatics. But such, only, should be selected for use by the surgeon, as imitate, hasten, or assist the natural processes of hæmostasis, or excite analogous ones: that is, such as act by arousing the contractility and retractility of the coats of arteries and veins and capillaries, thus lessening the size of the apertures; or, by forming occluding coagula artificially, thus plugging and closing the apertures completely; or, by exciting adhesive inflammation within and around the apertures, thus making their closure permanent. The most important of these hæmostatics will be enumerated.

I. Cold.—The employment of cold has been handed down from ancient times. Celsus directs it to be used for stopping hemorrhage. Rhazes advises the application of snow for the same purpose. John Hunter saw the carotid artery of an ass markedly lessen when exposed. Baron Larrey states that, after the battle of Eylau, the mercury standing at about zero (Fahr.), ligatures were applied to the large bloodvessels only, in the operations generally, and that there was no trouble from hemorrhage, although the wounded, after having been cared for, were carried to a great distance.[2] In the use of cold, then, we have an ancient, handy, safe, and powerful means for arresting bleeding. It may be applied in the form of fresh cold *air*. Merely opening

[1] Op. cit., p. 185.

[2] Memoirs, vol. ii. p. 32, Am. ed.

a wound, removing the clots, and exposing its bare surface to the contact of fresh cold air, has often stopped at once a hemorrhage which had continued to be free, as long as the wound was kept closed and covered up with pledgets and bandages. Wounds are often left open for a considerable time solely for the purpose of obtaining the hæmostatic influence of the atmosphere. The energy of atmospheric cold may be considerably increased by fanning the exposed part. Cold may also be applied in the form of water or of ice. Compresses soaked in cold *water* may be laid on, and, when frequently renewed, they exert a powerful hæmostatic influence. Cold water, too, may be squeezed from the pores of a sponge in showers upon a wound; or, it may be thrown in a small steady stream from the nozzle of a syringe. This plan usually effects rapid contraction in the small vessels that are wounded, and thus quickly stops their bleeding. Sometimes, in operations about the air-passages, it is especially important to employ cold water thrown in a fine stream upon the incision, with a small syringe. Finally, cold may be applied in the form of *ice*. When hemorrhage occurs within the cavity of the uterus, or of the rectum, or of the mouth, suitably shaped fragments of ice may often be laid, with great advantage, directly upon the bleeding surface. In cases where dry cold of great intensity is required, it may readily be obtained by placing pounded ice or freezing mixtures in bladders or India-rubber bags adapted for the purpose.

II. Alcohol.—Applied to a raw surface, alcohol excites a severe smarting pain, with a considerable contraction of the wounded bloodvessels; it also coagulates the blood itself. As an external application alcohol, in a natural or an artificial form, has, from remote antiquity, been used as a dressing for wounds. The ancient use of oil and wine for this purpose is well known. In the seventeenth and eighteenth centuries, alcohol was extensively employed as a dressing for incised and other clean wounds, and its ability to suppress bleeding was then noted. Recent observations also attest its excellence in arresting hemorrhages, by causing the wounded vessels to contract, and by coagulating the albumen of exuded plasma. It may be applied in the form of rectified spirit, by moistening a soft sponge therewith, and gently pressing it upon the bleeding surface. Alcohol is also useful for dressings to wounds in other respects, for it prevents the putrefaction of discharges, and promotes cicatrization.

III. Oil of Turpentine.—John Hunter termed this "the best, if not the only true styptic," and its efficacy justifies this high estimate of its value. In external traumatic hemorrhages it has proved efficient; and it has been used with success in almost every other form of hemorrhage. It has been used with most success, however, in cases where the bleeding was passive. The particular affections for which it has been successfully prescribed are *epistaxis*, *hæmatemesis*, *hæmaturia*, *menorrhagia*, *post-partum bleeding*, and the multiple bleedings occurring under the influence of the *hemorrhagic diathesis*. It acts by arousing the contractility of the vessels that are opened and bleeding. It may be used internally as well as externally with advantage. It may be applied by saturating dossils of lint, and placing them upon the bleeding points. Internally, it may be administered in doses of ten or fifteen drops suspended in mucilage, emulsion, or yolk of egg, every hour or two, until relief is obtained. By giving ten drops, in simple emulsion, every fifteen minutes, I once saved a case of prolonged epistaxis that had been considered almost hopeless. The liability of turpentine to irritate the bladder should not be forgotten.

IV. Perchloride and Persulphate of Iron.—Solutions of these acid salts of iron have been much employed for arresting hemorrhages. Both preparations are powerfully astringent and hæmostatic. The perchloride, however, is the more irritating. It is of interest to learn, if possible, in what manner its solution acts in suppressing hemorrhage. Undoubtedly it coagulates the blood itself. When a small artery is allowed to bleed into a saucer containing a mixture of two parts of the liquor ferri perchloridi and one of water, this mixture converts almost at once six or eight times its bulk of blood into a tough, hard clot, and for a long time preserves it from putrefaction. But Broca has shown that this coagulating action is not instantaneous, but requires about thirty seconds for its completion; so that if this mixture, or any other solution of ferric chloride, be applied to a part from which the blood is flowing freely, its styptic influence cannot be exerted upon the vessels themselves from which the blood escapes. But such an influence is essential to the satisfactory arrest of a hemorrhage. Dr. Barnes, who first brought this remedy into vogue, employed a mixture of one part of the stronger solution of ferric chloride and three parts of water, which he applied, by injecting it through a tube, directly to the bleeding surface of the uterus. As a hæmostatic for external use, five parts of the salt may be dissolved in one hundred parts of distilled water, and lint soaked with this mixture may be applied to the bleeding surface.

But Monsel's solution of the persulphate of iron has probably been used, in this country at least, as a local hæmostatic, much more than the ferric chloride. It has the advantage of being less irritating than other acid salts of iron. It has been applied by a stiff brush, or a fragment of compact sponge; or by laying a pledget of lint soaked with the solution, upon the bleeding surface.

Both of these preparations, however, have been more popular than they have deserved to be. Neither of them directly or immediately excites the opened vessel to contract. Both of them, also, as well as the other acid salts of iron, produce a hard insoluble coagulum, which is very difficult to detach, and which greatly interferes with the apposition and healing of all deep wounds where these substances have been applied. Their employment is, therefore, to be deprecated in all surgical hemorrhages except those which are tegumentary or superficial, as for instance, those caused by leech-bites; but to them, the solutions of these ferric salts may be applied with advantage. They may also be used with much benefit in cases of parenchymatous hemorrhage occurring in open wounds.

There are many other astringent substances which coagulate the blood, and may thus suppress hemorrhage by filling with clot the wound from which the blood issues, that is, by plugging it. Among them the most important are *tannic* and *gallic acids*, *alum*, *nitrate of silver*, and *chloride of zinc*. But they are all liable to the same objections as the acid salts of iron, which have just been explained. Alum, however, is the least objectionable. It should be dissolved in warm water, and applied in a tepid state, for then it will be deposited in fine crystals about the mouths of the opened vessels. A sharpened stick of nitrate of silver too, may sometimes be applied with advantage for arresting hemorrhage in leech-bites. But, I believe that in all deep wounds, the employment of astringent substances, whether mineral or vegetable, excepting perhaps alum and alcohol, ought to be shunned, because the occluding coagula which they produce interfere not a little with the apposition and healing of such wounds.

Besides the oil of turpentine, there are several other agents which, when given internally, are useful for suppressing hemorrhage. They are the *oil of*

*erigeron*, the *acetate of lead*, *opium*, *dilute* or *aromatic sulphuric acid*, and *ergot*. They act by causing the wounded vessels to contract. The Oleum Erigerontis Canadensis is a nervo-vascular excitant which may be administered in doses of ten or fifteen drops every two or three hours. The plumbic acetate is very widely applicable and effective as an internal hæmostatic. For such a purpose, the dose of acetate of lead should not be less than two grains every hour; and, generally, it should be combined with opium. As much as five grains every hour has been used successfully, and without damage. Opium proves useful by allaying pain and nervous excitability, as well as by causing vascular contraction. It should be given in small doses at short invals, as, for instance, half a grain every two hours. The diluted and the aromatic sulphuric acid have often been given with good effect for hemorrhages from the portal system, in doses of fifteen drops largely diluted with water, every two or three hours. Ergot is now popular as a hæmostatic. The best form of it for administration is the fluid extract, of which thirty or forty drops may be given every half hour until relief is obtained.

## Surgical Treatment of Hemorrhage.

Under this head, the mechanical expedients employed for suppressing hemorrhages will be severally described. They are (1) position, (2) compression, (3) ligation, (4) torsion, (5) constriction, (6) acupressure, (7) aërteriversion, and (8) cauterization.

### I. Position.

On lifting up or raising a thigh-stump after amputation, I have often noticed that the bleeding from the femoral vein generally ceases at once, and that, on depressing it again, the bleeding may recur. Thus by position the force of gravitation may be employed to lessen the tendency of blood to flow from wounded vessels. The wounded part should generally be elevated by placing it upon an inclined plane, or a pillow, or a cushion, of suitable height. This proceeding has considerable value in the treatment of venous hemorrhage, especially that which occurs in the lower extremity.

The position of *extreme flexion* is worthy of notice, as well as the elevated position. The acute angle in the course of the main artery which the extreme flexion of a limb occasions, presents a considerable obstacle of a mechanical nature to the flow of blood through the bent artery. This plan has been successfully employed in the treatment of aneurism. It may also be used to restrain hemorrhage from wounds near the hand or foot, and is accomplished by forcibly bending the forearm upon the arm, or the leg upon the thigh, or the thigh upon the abdomen, and so retaining them by several turns of a roller. This position, however, is always uncomfortable, and sometimes intolerable, to the patient, and, therefore, should be employed as a hæmostatic only temporarily, or from want of better means.

On the occurrence of *convulsio syncopalis*, or even of syncope from extreme loss of blood, a depressed position of the patient's head must be constantly preserved until recovery takes place. Moreover, in such cases, the limbs must not be allowed to fall down from the couch, and thus assume a depending position, for the sinking of blood into them by the force of gravitation would notably increase the cerebral anæmia, and the danger of a fatal issue.

## II. Compression.

This mode of treatment consists of applying to the bloodvessels a sufficient degree of pressure to stop the circulation through them, or to prevent the escape of blood from their open mouths, when wounded.

The compression is called *lateral*, when the pressure acts upon the sides of bloodvessels, and perpendicularly to their length or course.

It is denominated *direct*, when the pressure is made upon the ends of divided bloodvessels, or within the apertures of those that are wounded, in a line coinciding with their length or course.

It is styled *immediate*, when the means or the instrument through which the pressure is exerted acts upon the bleeding orifice itself without the intervention of anything else, that is, immediately. By many this mode of compression is also called direct.

It is entitled *mediate* compression when the pressure is brought to bear upon the vessels through intervening tissue or soft parts.

Lateral compression may be made on a bloodvessel at the place where it is wounded, or between it and the heart; or, again, it may sometimes be required beyond the wound, that is, on the distal side thereof. Lateral compression, when applied to arteries, pushes them before it, and crowds them into the soft structures upon which they rest. Now, if these structures have no solid support, they yield; thus the compression is evaded, and it proves insufficient to arrest the flow of blood, however strong it may be. Hence, lateral compression can be usefully applied only to such arteries as have beneath, and not too far distant, a solid support in the shape of bone.

Compression of arteries may be effected with *the fingers*, with *pads*, *tampons*, or *compresses*, with *tourniquets*, and with *Esmarch's apparatus* for bloodless operations.

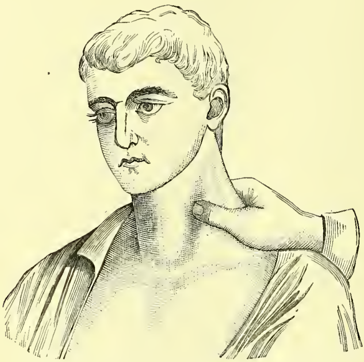
Digital Compression, in violent hemorrhages from recent wounds, is well adapted to stay the bleeding until ligatures can be applied. When a finger commands an artery, there is no danger as long as its command continues. Digital pressure may be applied immediately to the bleeding apertures in the vessels themselves, by inserting the fingers into wounds. In a considerable number of cases related in this article, compression employed in this way saved life, when, otherwise, it could not have been preserved. In many instances this proceeding can be executed by the patient himself.

But, digital compression may be laterally applied to arteries, with success, whenever they run near enough to bones for a fixed point of resistance to be afforded thereby. The following are the principal places where this use of pressure made with the fingers can be employed:—

For the *common carotid artery*, the fore-part of the side of the neck, between the larynx and the inner border of the sterno-mastoid muscle, is the place where that vessel can be compressed against the transverse processes of the vertebræ. To effect this, the thumb of the opposite hand (*e.g.*, that of the right hand for the left carotid, and vice versa) should be placed at the inner edge of the sterno-cleido-mastoid muscle, opposite the lower edge of the thyroid cartilage, and thrust backward, downward, and inward, so as to force the artery away from the vein and against the transverse processes of the cervical vertebræ; the fingers crossing the median line of the nape, but making no counter-pressure. The energy of the compressing force can be much increased by adding to it that of the other thumb. By many it is held that the common carotid artery may, with peculiar advantage, be compressed against the so-called tubercle of Chassaignac on the transverse process of the sixth cervical

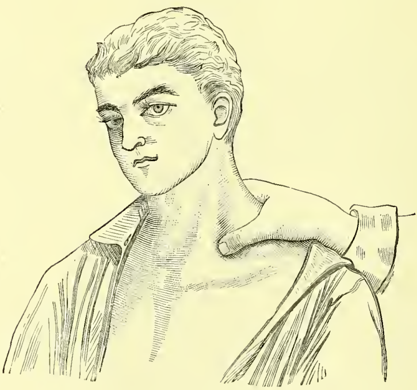
vertebra, in a manner similar to that shown in the accompanying wood-cut (Fig. 342), the pressure being applied two or three inches above the upper border of the clavicle.

Fig. 342.



Digital compression of the carotid artery. (Esmarch.)[1]

Fig. 343.



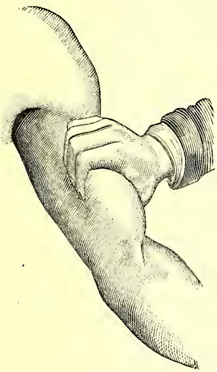
Digital compression of the subclavian artery. (Esmarch.)

For the *subclavian artery*, the supra-clavicular fossa is the spot where the thumb should be applied in order to compress the artery against the first

[1] Permission to copy this wood-cut and many others that follow it, to which his name is attached, has been generously given to the writer by the distinguished Surgeon-General of the Prussian Army, for which courtesy it is but just to make this acknowledgment.

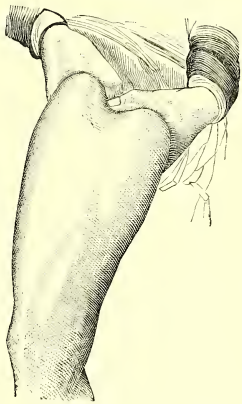
rib, after its issue from behind the scalenus anticus, and in the third part of its course. (Fig. 343.) By drawing the shoulder forward, and with it the clavicle, more room may be obtained for applying the pressure to the artery. This vessel is so deeply seated, however, that it is often wise to employ a substitute for the fingers to compress it against the first rib; and the best substitute is a common door-key, of good size, the handle of which should be covered with the turns of a narrow roller. It should be firmly pressed downward into the subclavian hollow of the neck, immediately above the clavicle. The tourniquet of Petit, when reversed, affords a thumb-piece, which, enveloped in a roller, may be used in the same way as a door-key.

Fig. 344.



Digital compression of the brachial artery. (Esmarch.)

Fig. 345.



Digital compression of the femoral artery. (Esmarch.)

For the *axillary artery*, the anterior fold of the arm-pit marks the spot where, when the arm is raised, the artery can readily be compressed against the head of the humerus, with the fingers.

For the *brachial artery*, the centre of the upper arm is the place where, at the inner border of the biceps, this vessel can easily be compressed against the humerus. (Fig. 344.) The fingers should be placed over the artery, along the inner edge of the biceps muscle, with the thumb on the opposite side of the limb.

The *abdominal aorta*, when the walls of the belly are relaxed and the intestines empty, can be compressed against the spinal column on a level with the umbilicus. To effectually make digital compression of the abdominal aorta, the patient must be in a recumbent position, with the shoulders raised and the limbs drawn up, so as to relax the abdominal parietes; three fingers of one hand should be placed over the artery, somewhat to the left of the umbilicus, the thumb stretching toward the other flank; and the fingers of the other hand should be placed upon those of the first, in order to make the pressure strong enough to completely flatten the vessel. This pressure, however, cannot be borne for any considerable length of time, unless a narcotic or anæsthetic be administered.

The *common iliac artery* and the *external iliac* in the upper part may be

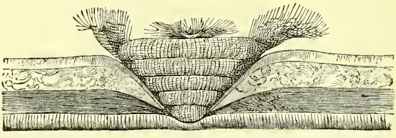
compressed in a similar way against the brim of the pelvis. But the latter can be compressed more readily and for a longer time against the upper border of the horizontal ramus of the pubis, just previous to its exit from the pelvis, above the middle of Poupart's ligament.

The *femoral artery* can easily be compressed against the ilio-pectineal eminence, just below Poupart's ligament. It is found in the middle of a line drawn from the anterior superior spinous process of the ilium to the symphysis pubis. When the current through this artery is to be restrained, the thumb may be placed upon the vessel at this spot, while the fingers grasp the outer part of the thigh; but when the pressure is to be applied lower down, both hands must be used, one thumb being placed upon the other, with the fingers embracing opposite sides of the limb (Fig. 345). In this way the femoral artery may be compressed against the femur as far down as the lower third of the thigh; but, low down, digital compression is difficult and uncertain, because of the thickness of the parts lying over the vessel, at least in fleshy subjects.

Pads, Tampons, or Compresses, are often applied to wounds with advantage for the suppression of surgical hemorrhages, until such time as ligatures can be applied. In case of their employment the pressure is exerted by means of a bandage. But before a compress is applied in this way, the injured part, if it be an extremity, must be carefully bandaged (with flannel if possible, for it is the best material for the purpose) from below upward until the whole limb is covered, in order to prevent the occurrence of diffuse infiltration of the connective tissue with blood, or sanguineous infiltration of the limb—a very dangerous complication. A firm pad, made if possible of antiseptic material, is then placed upon the wound, and firmly pressed upon it by a tightly-drawn bandage. This part of the proceeding is best accomplished with a bandage made from some elastic material; for instance, India-rubber or elastic braces.

But if a large artery is opened, it is safer to apply a *conical tampon* in the wound itself. For this purpose a square piece of antiseptic gauze, or of muslin soaked in carbolated oil, is pressed with a finger as deeply as possible into the wound, and then the cavity is filled, as the finger is withdrawn, first with small, then with larger antiseptic balls of prepared jute or wadding, until the last overlaps the margin of the wound. (Fig. 346.) The wads

Fig. 346.



Application of a conical tampon made of antiseptic balls. (Esmarch.)

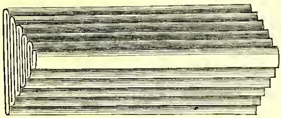
should be quickly and firmly put into place. The whole is kept in position by a tightly-drawn bandage; if possible, by an elastic one. On the arrival of the patient at the hospital, or at his home, the tampon must be removed; and if the hemorrhage return, or if the coats of the artery be perceptibly injured, a ligature must be applied to it, on each side of the wound, where its coats are sound.

*Graduated compresses* that are pyramidal, wedge-like, or elongated in shape, are not unfrequently applied also by means of tightly-drawn bandages to tem-

porarily restrain the flow of blood from recent wounds; but when they are not placed so as to press exactly on the bleeding orifice in the wounded vessel, they often do much harm. Especially is this the case when, from the faulty adjustment of such compresses, the wounded limb becomes widely infiltrated with extravasated blood.

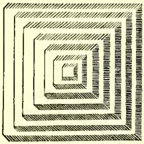
When after a few hours' delay, in cases where the compresses and bandages have been accurately applied, as directed above, we remove the dressings in order to tie the artery in the wound, we sometimes find that the aperture in the vessel has become closed by the contraction and retraction of its walls, aided by the formation of occluding coagula, and that the bleeding is permanently arrested. The procurement of the same result is often aided by a moderately-protracted syncope; and provided we keep the patient at rest, with a continuance of the same dressings to the wound, after carefully examining it, and abate all tendency to vascular excitement by giving cool acidulated drinks and an antiphlogistic regimen, we are sometimes gratified by finding that a permanent arrest of the hemorrhage has been secured.

Fig. 347.



Graduated compress (oblong). (Esmarch.)

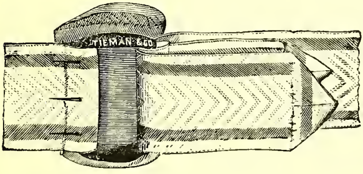
Fig. 348



Pyramidal compress.

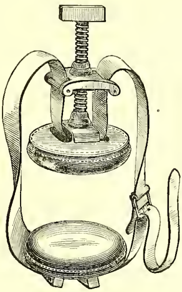
Tourniquets.—Inasmuch as digital compression cannot be successfully continued, for any length of time, except by a skilled and powerful hand,

Fig. 349.



Field tourniquet.

Fig. 350.



Charrière's screw tourniquet

tourniquets have been invented by surgeons to supply its place. Many varieties of this instrument are in use. Among the best, as well as the most widely known of them, is that of J. L. Petit. (See Fig. 105, Vol. I. p. 566.) It consists of two brass plates, each set in a frame of brass bars in which rollers turn, a strong thumb-screw to force the plates asunder, a strong strap,

and a strong buckle. To apply this tourniquet properly, the limb should first be enveloped with a few turns of a roller, in order to protect the skin from pressure. A square pad, made by folding a roller three inches wide and two yards long, should be placed over the artery to serve as a compress. Upon this the base of the instrument should be laid, its two plates having already been approximated, and the strap should then be carried around the limb and securely buckled. By turning the thumb-screw the artery may be compressed at will.

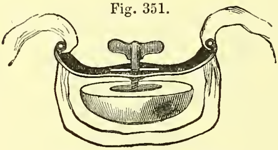
The field tourniquet (Fig. 349) is composed of a strong linen strap, a strong buckle, and a pad; and is, in substance, the strap and buckle of a Petit's tourniquet, which are to be used without the frame and screw of that instrument.

The tourniquet of Charrière (Fig. 350) is provided with a pad for making counter-pressure; but, in respect to efficiency, this instrument does not equal the tourniquet of Petit.

The well-known firm of Tiemann & Co., surgical instrument makers, have devised a useful tourniquet which bears their name (Fig. 351). In this instrument the pressure is applied to the artery by a pad which is projected by a screw. This tourniquet will not easily turn over, nor hinder the circulation of the venous blood.

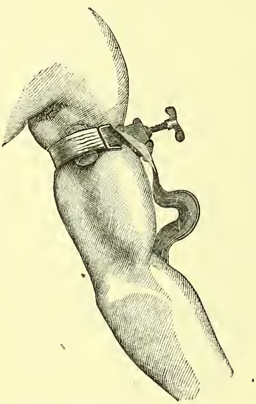
But the constriction of the limb which attends the employment of all tourniquets which act by means of a strap passing around the limb, is liable

Fig. 351.



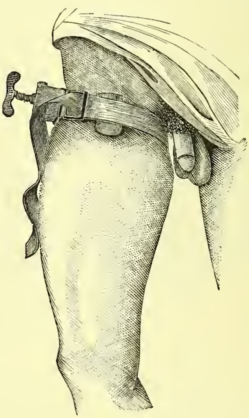
Tiemann & Co.'s tourniquet.

Fig. 352.



Compression of the brachial artery by a screw tourniquet. (Esmarch.) The tourniquet plate is displaced to show the application of the compress in the line of the artery; the plate is adjusted immediately over the compress before the strap is tightened.

Fig. 353.

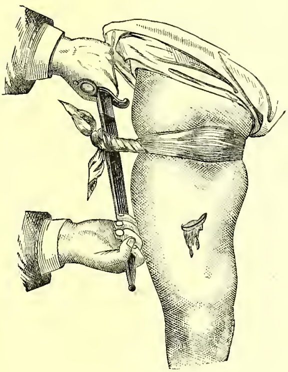


Compression of the femoral artery by a screw tourniquet. (Esmarch.) The plate of the instrument is adjusted over the compress before the strap is tightened.

to cause a great deal of pain, and this circumstance has led to the invention of many instruments which act only on the opposite sides of the limb. Among them must be mentioned the tourniquet or artery-compressor of Professor Gross. (See Fig. 110, Vol. I. p. 567.)

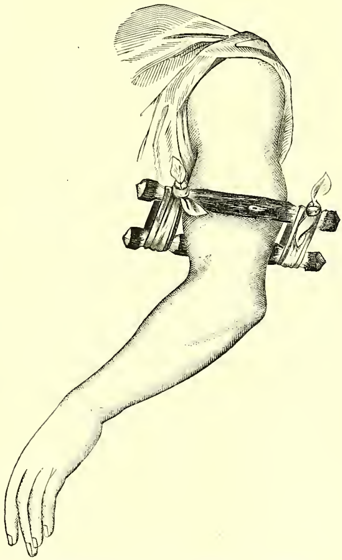
In default of the tourniquets already described, an effective instrument for compressing the main artery of the thigh, arm, etc., may be improvised in the following manner:—a pocket-handkerchief, or piece of muslin of corresponding size, folded into the form of a cravat and knotted in the middle, or containing a pebble placed at the same spot, for a compress, should be tied securely, but rather loosely, about the limb, and then twisted with a stick, a ramrod, or a bayonet, etc., inserted underneath. (Fig. 354.) I have several times known old soldiers to stop hemorrhage for comrades in this way.

Fig. 354.



Improvised torsion, or the old soldier's tourniquet (Esmarch.)

Fig. 355.



Improvised double-stick tourniquet of Völkers. (Esmarch.)

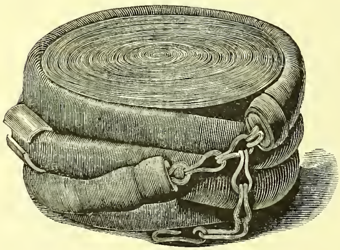
Comparatively little pressure, however, if exerted by means of a stick against the inner side of the arm, is sufficient to control the circulation in the brachial artery; the muscles may, in this way, be forcibly separated, partly forward, partly backward, and the artery pressed flat against the humerus. Völker's improvised stick tourniquet, which attains this object, may readily be prepared from two stiff shoots or branches of a tree, and two handkerchiefs. (Fig. 355.)

The blood-stream in the abdominal aorta can be most securely controlled, if the intestines have been previously emptied, by compressing the aorta

itself against the vertebræ, in the region of the umbilicus. For this purpose, Lister's or Pancoast's abdominal tourniquet (Figs. 111, 112, Vol. I. p. 568) should be employed. The pad is moved by a long screw, so as to act upon the aorta; the counter-pressure is furnished by the cushion for the back. The artery compressors of Skey and Erichsen may also be employed to control the circulation in the abdominal aorta.

Esmarch's Apparatus.—Esmarch's apparatus for the bloodless operation affords a very simple, a very efficient, and a very safe means of arresting the circulation. If an elastic band of India-rubber, whether round or flat, be wound with strong traction several times round a limb, and the ends fastened by a knot or safety pin, all the soft parts, and with them the arteries and veins, may be so firmly compressed that not a drop of blood can pass through. It is evident that the effects of an elastic band, when properly applied, must be continuous and lasting, while the strap of Petit's tourniquet soon stretches and thereby becomes inefficient. The elastic band also can be successfully applied in any position we may choose; and its employment does not require an intimate anatomical knowledge of the part which is subjected to compression. In urgent cases, an elastic brace may be used in its stead.

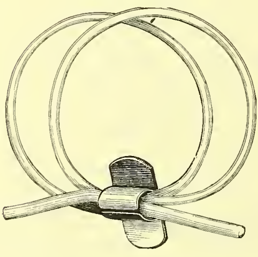
Fig. 356.



Esmarch's apparatus for elastic compression.

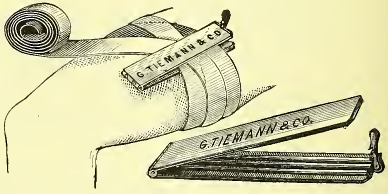
Esmarch's apparatus for performing operations on the extremities without loss of blood consists essentially of an elastic roller made of India-rubber, and an elastic tube or ligature, made also of India-rubber, with a chain and hook, or a ring, or a clamp, or a safety-pin for fastening the ends. In Fig. 356 an elastic roller is

Fig. 357.



The elastic tube or ligature fastened with a brass ring.

Fig. 358.

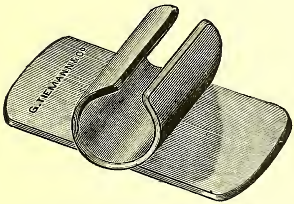



Langenbeck's clamp for fastening Esmarch's elastic roller.

represented, together with an elastic tube or ligature wound around its exterior, and fastened with a hook and chain. Figs. 357, 359 and 360 show the mode of securing the apparatus with a ring, and Fig. 358 the mode of

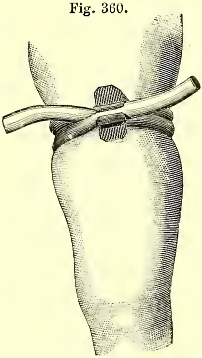
accomplishing the same end with a clamp. Figs. 362 and 363 show the application of Foulis's device for effecting the same purpose.

Fig. 359.




The open brass ring for fastening the elastic tube.

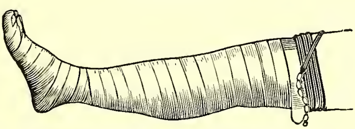
Fig. 360.



Elastic tube or ligature drawn tightly round the thigh, and fastened with a brass ring, compressing the femoral artery. (Esmarch.)

Although it is not strictly within the scope of this article, I will in a few words describe the process of rendering a limb bloodless by the method of Esmarch, for in this connection it will be of interest to all readers. The member having been covered with oiled silk or varnished paper to prevent soiling of the bandage, an *elastic roller* is firmly applied to it from the tips of the toes, or fingers, upward, until the site of the proposed operation has been passed; by this means the blood is driven completely out of the vessels. Where the roller ends, an elastic ligature, or tube of India-rubber, is wound with moderately strong traction several times around the limb, compressing the arteries so that no more blood can pass through them; and the ends are fastened together by a hook and chain, or by some other approved method.

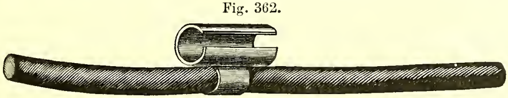
Fig. 361.



Right foot and leg with the elastic roller and ligature in place.

Fig. 361 represents the right foot and leg with the elastic roller and the elastic tubing or ligature *in situ*. The elastic roller, together with the oiled silk,

Fig. 362.

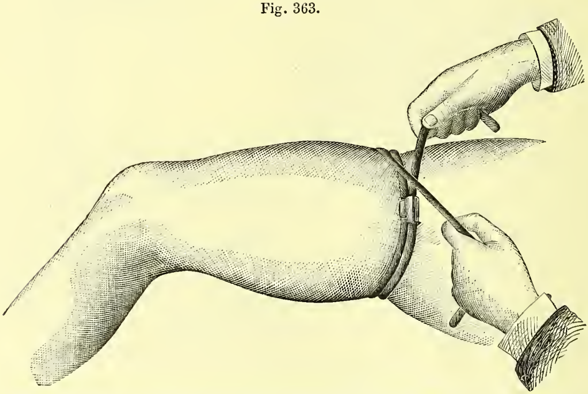


Foulis's fastening apparatus for the elastic ligature. (Esmarch.)

is next removed, but the elastic tubing or ligature is left on to act as a tourniquet, and, provided that the apparatus has been properly applied, the limb below this tourniquet exhibits a completely blanched appearance, like that of a corpse. Any operation can now be performed without loss of blood.

But parts of limbs which contain unhealthy pus, must not be firmly bandaged with the elastic roller, because infecting matter might thereby be driven upward into the connective tissue, and into the lymphatics. In such cases one must be satisfied with holding the limb in an elevated position for

Fig. 363.



Showing compression of the femoral artery with Esmarch's elastic ligature, and the application of Foulis's fastening clasp or ring. (Esmarch.)

a few minutes in order to make the blood run out of it, as practised many years ago at the New York Hospital by the American surgeons, Mott and Stevens, before applying the elastic tubing or ligature to control the circulation.

Nicaise's modification of the elastic roller and ligature is recommended on the high authority of Esmarch. It consists of a strong India-rubber belt, to one end of which are fastened a hook, and a number of rings one after the other. (Figs. 364 and 365.)

The application of Esmarch's tube to the axillary artery is shown in Fig. 366.

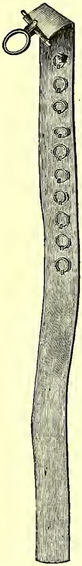
To arrest the circulation of blood in a finger, an India-rubber tube, about the size of a goose-quill, suffices; it should be wound around the finger two or more times, its ends crossed on the back of the hand, then carried around the wrist, and tied on its dorsum.

An elastic ligature of similar size, and constructed of the same material, when tightly drawn around the root of the penis and scrotum, will restrain the outflow of blood from the arteries of these parts. (Fig. 367.)

To compress the common femoral artery, the India-rubber tube is wound once or twice around the thigh just below the groin, and its ends are crossed over the groin, carried around the posterior aspect of the pelvis, and finally hooked together over the hypogastric region. (Fig. 368.)

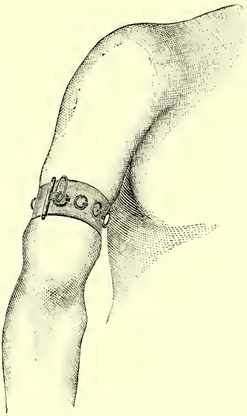
A pad consisting of a firmly rolled linen bandage may be placed as a compress over the external iliac artery, immediately above Poupart's ligament,

Fig. 364.



Nicaise's elastic belt for compressing the arteries of the extremities, and thus restraining traumatic hemorrhage. (Esmarch.)

Fig. 365



Nicaise's elastic belt applied to the arm for compressing the brachial artery. (Esmarch.)

and may then be energetically pressed down upon that vessel by several figure-of-eight turns of a strong India-rubber roller bandage. (Fig. 369.)

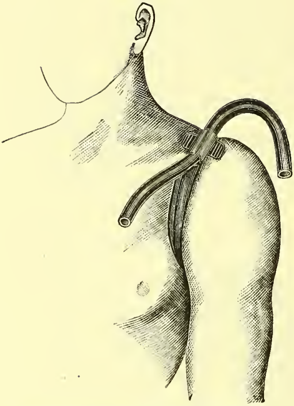
Should there be no abdominal tourniquet at hand, a pad may be improvised in the following manner:—A strong linen bandage about eight yards long and four inches broad, is wound around the middle of a stick about a foot long, and having the thickness of a thumb. This pad is placed just below the umbilicus, and is kept in position by an assistant. It should then be pressed with considerable force against the spinal column by many turns of an elastic bandage, four inches in width, each of which is wound around the body at the loins. (Fig. 370.)

But if circular compression of the abdomen be undesirable, the linen bandage should be wound around the middle of a stick long enough to have its ends embraced by the turns of an elastic bandage, which is passed underneath the operating table. (Brandis's method, Fig. 371.)

Whenever necessary, one or even both extremities may be kept bloodless for several hours without injury.

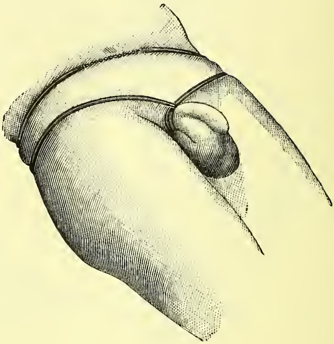
At the conclusion of an operation in which the elastic ligature has been employed, the ligature itself must *not be slowly* loosened, but be *quickly* taken off from the limb. The consecutive hemorrhage is generally considerable, because the walls of the bloodvessels are temporarily paralyzed. The hemorrhage must, therefore, be provided against, before removing the elastic ligature, either

Fig. 366.



Elastic compression of the axillary and other arteries at the shoulder. (Esmarch.)

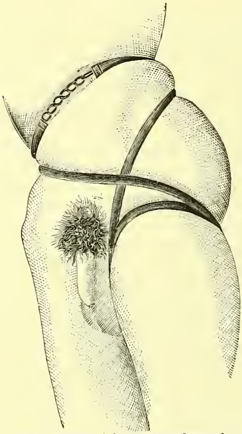
Fig. 367.



Elastic ligature applied to the penis and scrotum, for the purpose of restraining surgical hemorrhage therefrom. (Esmarch.)

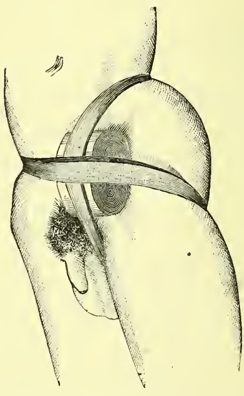
by tying the divided vessels (as in amputations, excisions, and in most open wounds), or by applying a tampon to the wound (as in necrosis cases, etc.).

Fig. 368.



Elastic compression of the common femoral artery. (Esmarch.)

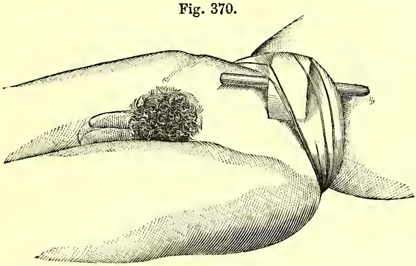
Fig. 369.



Elastic compression of the external iliac artery. (Esmarch.)

The parenchymatous bleeding which follows in spite of these measures is easily arrested by affusing the surface of the wound with carbolized iced

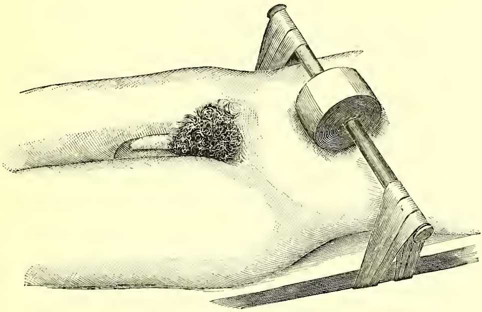
Fig. 370.



Improvised compression of the aorta, with a pad and an elastic roller. (Esmarch.)

water, or by applying the induced current to the same, or by compressing the main artery with the fingers, above the wound. (See also Vol. I., page 569.) If small arteries spurt, they must be tied or twisted.

Fig. 371.



Compression of the abdominal aorta by Brandis's method. (Esmarch.)

The elastic tourniquet of Esmarch, many ways of applying which have been given above, with illustrative figures, is in some respects superior to all other tourniquets, because it can be applied around any part of the limb, and because the location or course of the main arteries need not be considered while putting it on.

## III. Ligation.

The only truly efficacious means of arresting the hemorrhage from wounds involving large arteries, are compression and ligation, as Boyer in substance justly remarks. And the direct or immediate application of a ligature to a wounded vessel is by far the most satisfactory way to stop its bleeding. It affords a feeling of security which is yielded by no other plan of treatment, and enables the surgeon to leave his patient, at whatever distance, feeling, if the artery be sound where it is tied, that there is absolutely no risk of hemorrhage left behind. Acquaintance with the ligature as a hæmostatic

agent has come down to us from the most ancient times; but when and where it was first employed is now entirely unknown. It was, however, well known to Celsus in the first century after Christ; to Galen about the close of the second century; to Aëtius in the fifth, to Paulus Ægineta in the seventh, and to Rhazes in the tenth century. Moreover, Rhazes recommended the employment of two ligatures in order to suppress traumatic hemorrhage, of which one should be put round the artery on each side of the aperture, because blood might issue from the inferior portion of the artery, that is, regurgitant or distal hemorrhage might occur, if the distal portion of the artery were not also tied. Rhazes recommended the complete severance of the wounded vessel, so that its cut extremities might retract. Avicenna in the eleventh, Albucasis in the twelfth, and Averrhoes in the thirteenth century were well acquainted with ligation as a hæmostatic measure. The early modern writers on surgery mention all the ancient methods of arresting hemorrhage. Guy of Chauliac recommended the ligature on the authority of Galen and Avicenna. It was also recommended by Brunus, Theodoricus, Rolandus, and Lanfrancus. Thus it appears clear that the use of ligatures for arresting surgical hemorrhages was well known to the ancient surgeons, and was never forgotten, even in the darkest ages.

Nevertheless, the glory of introducing the ligature as a hæmostatic agent in *amputations* is unquestionably due to Ambroise Paré. In 1564 he published an account of his discovery, which, he says substantially, he was enabled to make by the special favor of the sacred Deity. But so slowly did the ligature make its way into general favor, that Sharpe, one of the surgeons to Guy's Hospital, writing in 1761, two centuries after its introduction into the great operations of surgery by Paré, found it necessary, in his well-known work, entitled "A Critical Enquiry into the Present State of Surgery," formally to advocate its employment for the arrest of hemorrhage from wounded arteries, in preference to styptics or the cautery, on the ground that "it was not as yet universally practised amongst surgeons residing in the more distant counties" of England. But why did it take two centuries to diffuse everywhere the employment of the simplest and the best surgical means which we possess for suppressing surgical hemorrhages? The reason simply was that surgeons in general were quite ignorant of the natural process of hæmostasis, and, consequently, knew not how the ligatures should be applied, nor of what form and material they should be made. Indeed, it was not until Dr. Jones, by appealing to experiment, and by a series of admirably-conducted investigations, showed that the division of the internal and middle coats of the artery, while tightening the noose, the very thing that surgeons then were most anxious to avoid, was the point on which the patient's safety actually depended, and pointed out the form and size of ligature that was most safe, the amount of traction which should be used in tying it, and the processes employed by nature for making the occlusion of the vessel permanent; it was not until all this was done by Dr. Jones, that surgeons in general acquired full confidence in the ligation of bloodvessels as, *par excellence*, the hæmostatic measure.

Avicenna recommended the employment of a "flaxen thread" for the ligation of wounded arteries. In our day, the materials chiefly used for making ligatures are silk, hemp, flax, silver, lead, iron, and the tissues of animals. Those of uncolored silk, soaked for half an hour in carbolized wax in a melted state, are preferred by many surgeons. There are two kinds of silken thread which answer best, the saddler's and the dentist's. But, whatever the material may be, the ligature should be round in shape, and should correspond in size to the artery to be tied. For small vessels it need not be larger than ordinary sewing-silk, and this size is large enough for the radial,

ulnar, anterior temporal, facial, etc. For the femoral, iliac, axillary, subclavian, or carotid arteries, saddler's silk is sufficiently stout to supply the ligature; and for the largest arteries, saddler's silk, when doubled, affords a ligature of sufficient size and strength. Ligatures should be cut from nine to twelve inches in length. They should also be well waxed, for thus their limpness is overcome, their knots hold better, and they prove less irritating from the coating of an animal substance which they have received; the best ligatures, however, consist of carbolized strings of animal origin, as for instance, catgut, kangaroo sinews, whale-tendons, etc.

Arteries that are wounded must always, if possible, be secured by ligatures at the very place where they are wounded. For this purpose the wound in the exterior parts must be sufficiently enlarged under the guidance of the fingers, and the blood-clots thoroughly cleared out with the fingers or with a carbolized sponge. And, while the exterior parts are held asunder with retractors, the surgeon must, carefully prepared and guided by a good knowledge of anatomy, proceed toward the bottom of the wound until the injured artery is found. He then must separate it from its cellular sheath, carefully ligate it above and below the injured spot with carbolized catgut, and divide it between the two ligatures, so that both ends of the divided vessel may be able to retract.

If, notwithstanding this double ligation, blood still wells up from the bottom, some other vessel must be injured. Such bleeding often results from the injury of a branch which is given off from the posterior wall of the main artery at the wounded spot. To ascertain this condition of things, the injured piece of artery between the two ligatures may be cut out. Or the bleeding may proceed from some other branch which is injured in the further course of the wound. In either case, the vessel must be sought for, and an attempt to close it with a ligature must be diligently made.

If, besides the artery, a large vein be wounded, this is made known by the fact that, in spite of the ligation of the artery, dark blood in large quantity flows from the wound, especially if pressure be made at a higher point. Such venous hemorrhage may generally be arrested by a light compress or by the tampon; but if not, the injured vein must also be tied in the wound.

These operations are often difficult; they can, however, be made easier by employing Esmarch's apparatus for elastic compression. (Fig. 356.) But, to drive out all the blood from the limb is not recommended, because one cannot then easily recognize the empty veins, nor avoid injuring them. It is therefore sufficient to apply the elastic bandage above and below the wound in such cases. The circulation is thereby entirely arrested, while the veins remain full, and can always be quickly refilled by a momentary loosening of the lower or distal bandage, should the blood escape from them in the course of the operation.

Moreover, in performing this operation, on which the life or death of the patient depends, no dread ought to be entertained of enlarging a small stab or a shot-hole into a very wide and deep wound, when necessary to lay bare and tie the bleeding vessel.

If this operation of tying the injured artery in the wound, which is called direct ligation, be impracticable, on account of the depth or the relations of the injured artery, or because the wound is closed, and it is not desirable to open it again, as, for instance, after amputation or excision, the trunk of the bleeding artery must be ligated at the nearest convenient spot, on the plan of Anel's operation.

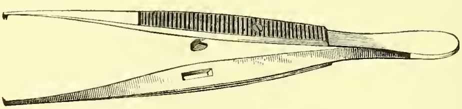
After the hemorrhage has been suppressed, antiseptic dressings must be applied, and drainage tubes should also be inserted whenever suppuration is likely to occur.

Instruments Required for the Ligation of Arteries.—Much ingenuity has been exhibited in devising instruments for operating on wounded bloodvessels. Hence the surgeon is well equipped with those which are needed for tying the deep as well as the superficial arteries; also for securing them in particular regions, and in their continuity as well as in open wounds.

When ligatures have to be applied to arteries in open wounds, as, for instance, after amputations, the mouth of each artery must be seized and drawn out from the tissues in which it is buried. For this purpose the tenaculum invented by Bromfeild, surgeon to St. George's Hospital (Fig. 134, Vol. I. p. 575), is much used in America, and in many cases does extremely well. Some care, however, should be exercised in using it; for, it is liable to pierce other structures along with the artery, an accident which, in general, should be avoided; and, inasmuch as it seizes an artery by perforating its walls, it has several times happened after its employment that dangerous, and, in one case at least, observed by Erichsen, fatal hemorrhage occurred from ulceration of the artery where it had been accidentally punctured by the instrument above the part around which the ligature was applied.

But the forceps in common use are, upon the whole, to be preferred as instruments for seizing and drawing out the ends of divided arteries, in order that ligatures may be put around them, in open wounds. There are several varieties of artery forceps, some having rat-toothed and others serrated points, some having narrow and others broad blades, while still others are fenestrated, each of which modifications offers peculiar advantages. For ordinary vessels, such as demand the ligature in common operations, an instrument like that represented in figure 372, is preferable. Its blades are long and slender, and fastened when closed with a spring-catch, while its points are fine and rat-toothed.

Fig. 372.



Spring-catch artery forceps.

One of the simplest and best instruments for drawing out and holding the main artery of a limb to be tied in an open wound, is Langenbeck's artery forceps. (Fig. 373.) Its points are serrated, and its blades can be fastened together by a button-slide. Moreover, the convexity of the instrument when closed facilitates the application of a ligature.

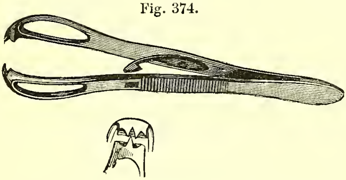
Fig. 373.

Langenbeck's artery forceps.

Another very useful instrument for the same purpose is Professor Hamilton's modification of Liston's artery forceps. (Fig. 374.) A serrated surface is placed behind the teeth at the end of the blades, by which their hold upon the artery is made more secure. With this instrument the surgeon can tie

an artery without an assistant, as it will retain its hold, and by its weight will draw the vessel out while the ligature is being applied.

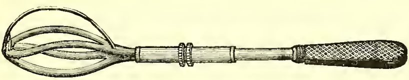
Fig. 374.



Prof. Hamilton's spring-catch fenestrated artery forceps.

Among the best of the fenestrated instruments must be reckoned Dr. David Prince's tenaculum forceps. (Fig. 375.) As its name denotes, the extremity of one of the blades is armed with a long slender tooth capable of piercing the walls of an artery like a tenaculum. The blades themselves are held securely fastened together when closed by pushing a tube down over them. With this instrument also the surgeon can readily take up an artery without an assistant.

Fig. 375.

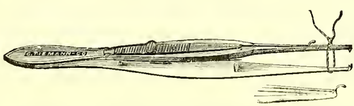


Dr. David Prince's tenaculum forceps

For the purpose of separating or detaching the sheath from the artery when about to tie it in a wound, and for many other objects, the plain forceps (Fig. 143, Vol. I. p. 578), can be advantageously employed.

For ligating deep-seated arteries, Professor H. J. Bigelow has devised a good as well as an ingenious instrument. When the artery has been seized, the operator closes the forceps, and by slightly moving the button forward, he locks the jaws. The ligature is then passed around the blades and partially tied. (Fig. 376.) By pressing forward the button the small hook will now expel the loop of the ligature from the blades on to the artery, whereupon the second knot is tied and the forceps removed.

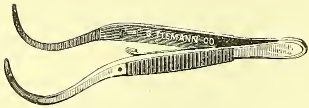
Fig. 376.



Professor Bigelow's forceps for tying deep-seated arteries.

For taking hold of meningeal arteries when required during resection of the cranial bones, etc., Professor J. S. Wight, of the Long Island College Hospital, Brooklyn, has invented a good form of forceps. (Fig. 377.) The instrument is four inches and three-quarters long. The jaws are curved, about an inch and a half long, and perforated near the ends, so as to introduce a ligature for arteries or tumors. It is fastened when closed by a spring catch.

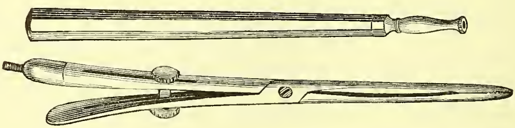
Fig. 377.




Professor Wight's meningeal artery forceps.

Intimately connected with the subject of the ligation of vessels are such instruments as the artery compressor, invented by Professor Gross. (Fig. 378.) It is designed to control the bleeding from vessels too deeply placed to be reached by the ligature.

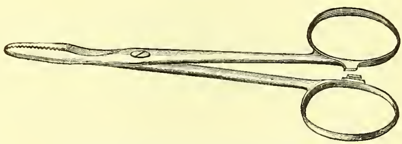
Fig. 378.



Professor Gross's artery compressor.

The artery and needle forceps of Professor Wight (Fig. 379) has also been successfully employed to produce hæmostasis in cases where deeply-placed vessels were wounded.

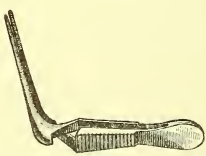
Fig. 379.



Professor Wight's artery and needle forceps.

Such instruments as small spring forceps (Fig. 380) and serres-fines (Fig. 381) are often valuable to the surgeon when it is desirable to complete an operation before applying the ligatures.

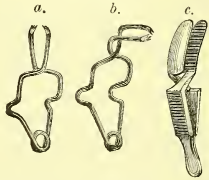
Fig. 380.



Milne's artery compression forceps.

Fig. 381.

*a.* *b.* *c.*

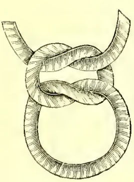


*a.* Straight serre-fine. *b.* Angular serre-fine. *c.* Langenbeck's serre-fine (known also as Nunneley's clip).

Mode of Ligating a Divided Artery.—In order to ligate a wounded artery, after exposing its open mouth to view, it must be seized with suitable forceps, or a tenaculum, and drawn out a little from its bed, where it must be steadily held by the surgeon, while, with plain artery forceps in the other hand, he carefully separates or detaches from it all the contiguous structures, but especially the accompanying nerves. The ligature must then be passed around the upper or proximal end of the wounded artery. No nerve must be included in the loop, for the ligation of a nerve causes always intense suffering, frequently muscular spasms in the injured limb—sometimes death from tetanus. Many examples illustrating and corroborating this statement—like that of Lord Nelson, whose sufferings were very great for four months after his arm was amputated, because a nerve had been included in the ligature put around the brachial artery—have been placed on record. The ligature must be drawn with just enough force to divide the inner and middle coats of the artery, the giving way of which the surgeon often distinctly feels. Next, a ligature must be applied to the lower or distal end of the wounded artery also, in an equally careful manner. Moreover, in applying both ligatures care must be taken not to draw the artery too far out of its sheath, because the destruction of the vasa vasorum consequent thereon might lead to sloughing of the artery-walls and secondary hemorrhage.

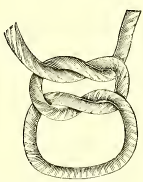
The ligature, having been drawn sufficiently tight, should then be secured or fastened with a reef-knot (Fig. 382), and without any pulling or dragging

Fig. 382.



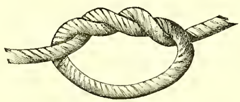
The "reef" or square knot.

Fig. 383.



The "granny."

Fig. 384.



The surgeon's knot.

of the artery itself. The "granny" (Fig. 383) must not be used, because it easily becomes loose. The surgeon's knot (Fig. 384), also, must not be employed in tying arteries, because it may fail to close the lumen of the vessel.[1]

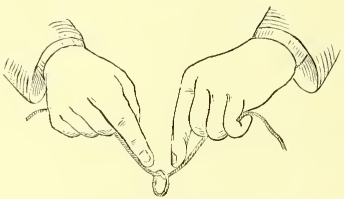
Boyer remarks that the surgeon's knot has the inconvenience of being tightened with difficulty, while at the same time it fails to entirely close the artery, even though great force be employed in tightening it; and that its disadvantage is proved by the following case: Chopart operated on a gardener for popliteal aneurism in presence of the most distinguished professors of the Ancient School of Surgery, by the old method. The ligatures being placed, and the first being tightened by the surgeon's knot, the compression was withdrawn, but, notwithstanding, the blood escaped abundantly. A second and a third ligature were placed and tightened in the same manner, and with as small success. The failure, after a moment's deliberation, was attributed to the ossification of the artery, or to some unknown cause, and it was decided to amputate. On examining the limb, however, the artery was found in a natural state; it was embraced by the three ligatures; but, although these ligatures had been tightened in the most for-

[1] These cuts are the same as Figs. 138, 139, and 140, in Vol. I. p. 576; they are reproduced here as a matter of convenience.

cible manner, neither of them had perfectly effaced the lumen of the vessel, but so incompletely that a large stylet could easily penetrate it. This fact is sufficient to proscribe the surgeon's knot forever in operations for hemorrhage, as well as in those for aneurism. I have, myself, often observed that ligatures tied with the surgeon's knot do not completely close arteries in the cadaver.

The tightening of the knot (which, as stated above, must always be a reef or square knot, and never a "granny" or a surgeon's knot, at least when tying bloodvessels) should be done with the tips of the index-fingers or the thumbs, placed near the knot itself (Fig. 385); taking care, also, that the thread is placed above the point where the forceps grasps or the tenaculum pierces the vessel to be tied.

Fig. 385.



Showing how to draw the knot.

When the tightening of the knot is finished, one end of the ligature, if it be of carbolized silk or similar material, should be cut off near the knot, and the other should be brought out of the wound. Every ligature should be carefully treated in the same manner, except in amputations, where it is customary to bring out both ends of the ligature pertaining to the main artery and knot them together, in order to distinguish this ligature from the others. The wound itself is then freed from all coagula, and carefully cleansed by washing or sponging with carbolized water or some other antiseptic liquid, the edges approximated and carefully secured in apposition by interrupted sutures and strips of adhesive plaster, an antiseptic dressing being placed over all. Thus the last step in the operation of *immediate* ligation of a wounded artery is completed.

Among our predecessors, the operation of *mediate* ligation, by which the tissues surrounding the artery were also included in the ligature, and thus the artery was compressed by the ligature through the medium of those tissues, was in vogue. In our own day, good surgeons still advise that diseased vessels—for instance, those that are calcified and have very brittle walls—should have a cushion of soft parts tied about them to the end that the ligature shall not separate too soon, or prior to the permanent occlusion of the canal by adhesive inflammation. Professor Agnew says that he has often adopted this plan with gratifying success. But in mediate, as well as in immediate, ligation of arteries, the accompanying nerves should be excluded from the ligature. Manec's plan of placing a piece of bougie in the tube of the artery before tying it, as well as the elder Cline's plan of using a flat ligature and interposing a piece of cork between it and the artery, and Scarpa's substitution of a piece of linen for the cork, are, however, of very doubtful value. The advantages of all similar contrivances are, too, exceedingly doubtful, for Agnew declares that he cannot recall an instance of secondary hemorrhage in such a condition of the arteries, where the ordinary ligature has been employed, and that he thinks the danger over-estimated. My own experience and views are in full accord with this statement.

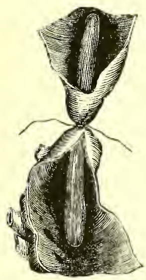
When the carbolized silk ligature is applied to an artery, its inner and middle coats are, in general, divided with more or less regularity, and the outer coat is so constricted as to completely arrest the flow of blood in the vessel at the place of ligation. (Fig. 386.)

A soldier, aged 27,[1] was wounded June 21, 1863, by a carbine-ball, which entered the left forearm two inches above the wrist, passed upward nearly to the elbow, and lodged. He was sent to Washington with the missile unextracted, and his arm much swollen. On the 29th an unsuccessful search was made for the ball. Sinuses extended along the radius, which was extensively denuded of periosteum. The patient was gradually failing. On July 3, the position of the ball having been found, it was cut down upon and removed. But, meanwhile, hemorrhage from the orifice of entrance commenced, and a tourniquet was applied to the brachial artery; it was loosened after the operation, without return of the bleeding. On the 5th, hemorrhage recurred, and compression of the radial and ulnar arteries by means of bandages was employed. On the 9th, "secondary hemorrhages being frequent, there was nothing left but amputation," which was accordingly performed just above the elbow. The patient's pulse came up after the operation; but anæmic exhaustion finally prevailed, and on the 11th he died. The brachial artery taken from the stump is shown in the accompanying woodcut (Fig. 386).

Fig. 386.

Showing a thrombus in the left brachial artery two days after amputation. (Spec. 1386, A. M. M.)

Fig. 387.

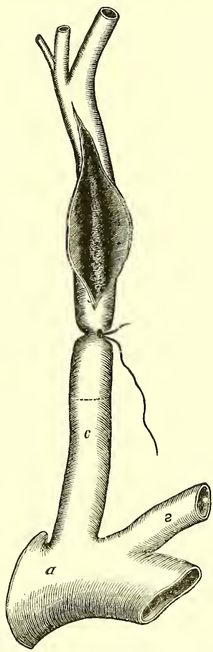


Showing the occluding coagula six days after ligation of the left subclavian artery. (Spec. 4089, Sect. I. A. M. M.)

But, when arteries are ligated in their continuity with silken threads, coagula should form in their tubes on the distal, as well as on the proximal, side of the ligatures. (Fig. 387.) In such cases the proximal is usually much larger than the distal clot.

A soldier, aged 35,[2] received, May 20, 1864, a gunshot wound, extending under the spine of the left scapula, forward and inward, toward the cavity of the chest. Gangrene attacked the wound, and extended deeply; secondary hemorrhage from branches of the left axillary artery occurred. On June 18, the left subclavian artery was tied in the outer third. On the 20th there were chills, followed by all the symptoms of pyæmia. On the 24th the patient died. Bromine had been applied to the gangrenous parts. The accompa-

Fig. 388.




Showing the coagulum in the distal part of left carotid six days after ligation; the distal much larger than the proximal coagulum. (Spec. 3179. Sect. I. A. M. M.)

[1] Med. and Surg. Hist. of the War of the Rebellion, Second Surg. Vol., p. 472.
[2] Ibid., First Surg. Vol., p. 540.

nying woodcut (Fig. 387) represents a wet preparation of a section of the ligated artery. The clots, both cardial and distal, are well shown.

The cardial or proximal is much larger than the distal coagulum in this specimen or preparation.

Sometimes, however, when arteries are tied in their continuity, a distal coagulum forms which is much larger than the proximal one (Fig. 388), as happened in the following instance:—

A soldier, aged 18,[1] received a gunshot fracture of the left zygoma and the left mastoid process, August 21, 1864. He was taken to the First Division Hospital, Fifth Corps, and on the 24th was transferred to the Lincoln Hospital at Washington. The wound extended from a point half an inch behind the outer canthus of the left eye to a point just behind the left mastoid process. Cold-water dressings were applied. On the 26th arterial hemorrhage occurred, which was checked by filling the wound with lint soaked in a solution of the persulphate of iron. It, however, recurred on the next day, and the left common carotid artery was ligated, under ether, above the omo-hyoid, an inch and a half below the bifurcation. Anodynes and stimulants were administered, but the patient sank under the repeated and copious hemorrhages, and died on September 2, six days after the ligation. At the *autopsy*, the meatus auditorius was found to have been cut across. It was impossible to detect from what vessels the hemorrhage had proceeded. Both lungs were anæmic. The specimen was sent to the Army Medical Museum. It is represented in the accompanying woodcut (Fig. 388). The vessels appear of the natural size, shrunken in alcohol. The letter *a* is placed on a portion of the aortic arch, the letter *s* on the left subclavian artery, near its origin, and the letter *c* on the trunk of the left common carotid. The ligature is represented *in situ*. The distal portion of the artery has been opened so as to show a firm fibrinous coagulum extending from the ligature to the bifurcation. The proximal coagulum is much shorter, occupying less than half an inch, the limit of its cardial end being indicated by a dotted line crossing the artery. The distal coagulum is more than thrice as long as the proximal.

The remarkable size which the distal coagulum attained in the case just presented, was, in all probability, due to the great freedom with which the blood flowed back or regurgitated into the internal carotid from its fellow of the opposite side and from the vertebral arteries, through the circle of Willis, when the common trunk was closed by ligation. Indeed, in no other part of the body is the communication between the terminal arteries nearly so free as it is between the internal carotids and the vertebrals at the base of the brain through the operation of this anastomosis.

Repair of Arteries after Ligation.—The permanent occlusion of an artery which has been tied in its continuity with a carbolized silk ligature, or with a ligature made of flax, hemp, iron, or silver, is effected in the following manner:—1. The coagula, both proximal and distal, shrink, become permeated with leucocytes, decolorized, hardened, and finally organized. 2. The inner and middle coats take on adhesive inflammation at the place where they are cut in two by the pressure of the ligature; that is, plastic lymph exudes from their cut edges, which heals their wound, and eventually unites them and the corresponding coagulum into a homogeneous mass. 3. The external coat also takes on adhesive inflammation, and organizable lymph exudes, whereby this coat is strengthened and consolidated. This inflammation is caused partly by the dissection required to expose the vessel, and partly by the pressure and irritation of the ligature. Plastic lymph is effused between the vessel and its sheath, cementing them together, and often inclosing the noose and knot within an ovoid mass. Progressively with the exudation of lymph and the formation of a fibrinous ring or band around the

[1] Med. and Surg. Hist. of the War of the Rebellion, First Surg. Vol., p. 314.

external coat where it is constricted by the ligature, which re-enforces and materially strengthens it, the part of the external coat that has been crushed in the embrace of the ligature disappears by ulceration, and the ligature itself separates, as it is termed, so that by gentle traction it may be withdrawn from the wound. The ligature having come away, the two ends of the artery which has thus been severed by it readily coalesce, and become cemented together with plastic material. (Fig. 389.)

Fig. 389.

Showing the common carotid artery permanently occluded, and the coalescence of its ends after separation of the ligature, ten days after ligation. (Spec. 3409. Sect. I. A. M. M.)

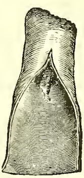
A corporal, aged 28,[1] was wounded in the face, Oct. 27, 1864, and on the 31st, was admitted to general hospital. A ball had entered the left side of the chin, passed inward, and lodged beneath the angle of the lower jaw, whence it was extracted through the mouth. Cold-water dressings and a compress to the jaw were applied. On Nov. 4, secondary hemorrhage occurred. It was arrested by plugging the wound with sponges. On the 6th the hemorrhage recurred, and the common carotid was tied just above the omo-hyoid; but, on the 16th, the patient died from exhaustion. The *autopsy* revealed a firm clot in the artery. The specimen was sent to the Army Medical Museum and is represented in the accompanying woodcut. (Fig. 389.) The proximal portion of the artery has been opened, so as to show the extent of the proximal clot.

The cause of death appears to have been anæmic exhaustion due to the losses of blood which had occurred prior to the operation.

The next example serves, likewise, to illustrate the process by which arteries become closed after they have had any of the so-called permanent ligatures applied to them:—

A soldier was wounded[2] on May 31, 1862, by a musket-ball, which entered the left mastoid process, passed beneath the maxillary, and emerged below the left eye. Secondary hemorrhage occurred on June 13 and 14; whereupon the left common carotid was tied above the omo-hyoid muscle; but death supervened on the 24th. The specimen was sent to the Army Medical Museum, and is represented in the accompanying wood-cut. (Fig. 390.) It consists of the proximal portion of the ligated artery, unconnected with the distal end, and has been laid open by incision so as to show a white fibrinous coagulum *in situ*. Apparently, the two ends had not yet grown together after separation of the ligature.

Fig. 390.



Showing the proximal end of the left common carotid artery after separation of the ligature, ten days after ligation. Externally, the end appears irregularly rounded, and its mouth is closed by the process of healing. Internally, it is completely plugged by a white fibrinous clot. (Spec. 508. Sect. I. A. M. M.)

In each of the two examples just presented the ligature came away in less than ten days. But the time required for the disengagement of a silk, or flax, or hempen thread will vary in almost every case, according to the size of the vessel and the amount and kind of the extraneous tissues embraced in the noose, from three days to three weeks. The removal of ligatures may be hastened by gently pulling upon the ends which project from the wound. All that remain after eight or nine days should be treated in this manner at every dressing of the wound.

The principal drawback to the use of the kinds of thread mentioned above for ligatures, and, indeed, to the employment of all permanent ligatures, is the fact that they must

[1] Med. and Surg. Hist. War of the Rebellion, First Surg. Vol., p. 393.
[2] Ibid., p. 396; also, Catalogue of Army Med. Musem, p. 460.

make their way through the vessels they embrace by an ulcerative process. For, in connection with this process under such circumstances, there are two sources of danger:—1. The walls of the artery may be extensively opened by sloughing, and thus the hemorrhage may recur. 2. The ulceration through the artery may take place before the clots in its tube are properly strengthened and fastened by the healing process, and thus, too, a failure of the operation may be wrought. The risk of sloughing, however, arises mainly from isolating the artery too much, or from separating it too extensively from its sheath, while dissecting to expose it or while preparing to pass a thread around it, whereby the minute vessels which nourish its coats are too extensively destroyed; hence the dangerousness of passing a spatula or the handle of a scalpel under the artery, and of dragging it out of its bed when tying it. The premature ulceration of a ligated artery is generally due to constitutional causes. It is, however, my belief that the risk of the occurrence of secondary hemorrhage after permanent ligations, when *properly performed*, is much exaggerated in many of the current statements. Still, the ulcerative process by which all permanent ligatures, no matter how skilfully applied, must make their way out, is unquestionably attended with more or less danger according to the case; and to avoid whatever there may be of this danger, threads made of animal tissues are now extensively employed for tying bloodvessels, in the hope that, after producing complete and permanent hæmostasis, they will themselves disappear by absorption, and that thus, while acting as temporary ligatures, they will give permanently good results.

Animal Ligatures.—The use of animal ligatures was first suggested in 1814, by Dr. Physick, of Philadelphia. Dr. D. M. Reese, the American editor of Cooper's Surgical Dictionary, which was republished in New York, in 1842, says: "To our distinguished countryman, Professor Physick, of the University of Pennsylvania, is undoubtedly due the honor of having first introduced what is known as the animal ligature into surgical practice. His ligatures are made of chamois leather, and he and the late Dr. Dorsey usually rolled their ligatures on a slab to make them round and hard. The advantages proposed by the ligatures of Dr. Physick are, that, being made of animal matter, the knot or noose, which is all that is left in the wound, will serve long enough to obliterate the artery, and be speedily removed by the absorbents, thus avoiding the difficulty arising from a foreign body, however minute. These ligatures have been used in this country to a great extent, and Sir Astley Cooper has demonstrated their superiority in his own operations. Dr. Hartshorne used strips of parchment for his ligatures. Dr. Jameson, Professor of Surgery in Washington Medical College, Baltimore, has for a series of years, been employing the animal ligature in an extensive surgical practice; a number of his operations I have witnessed. He has used it in many amputations of the limbs and mamma; he has tied the carotid, the iliac, the femoral, the radial, the posterior tibial, the spermatic, and other arteries, with buckskin ligatures, and in no instance had secondary hemorrhage; and he states that he has never seen anything of his ligatures, and of course his wounds have generally healed by the first intention. He also states, as the result of his observation and experiments upon sheep, dogs, and other animals, that a capsule will surround the ligature, if the capillary vessels be not much disturbed, or the vessel will be surrounded by an abundance of lymph, and the ligature dissolved."[1] In the supplement to the same work, Dr. Reese also says: "Dr. Eve, of Georgia, employs exclusively ligatures

[1] Cooper's Surgical Dictionary, edited by Reese, vol. ii. p. 130. New York 1842.

made of the tendon or sinew of the deer, when he expects union by the first intention; they were originally suggested by Dr. John Bellinger, of Charleston, South Carolina."[1]

Dr. McSweeny, of Cork, recommended the gut of the silkworm for ligatures; and Sir Astley Cooper at one time used catgut for the same purpose. He tied the femoral artery successfully with this kind of thread in a case of popliteal aneurism. But notwithstanding these successes, the animal ligature soon fell into disuse, and was remembered only as a historical curiosity.

To Mr. Lister is undoubtedly due the honor of having reintroduced the animal ligature into surgical practice; and he has shown that catgut, when properly prepared, possesses all the advantages for use in tying arteries that Physick claimed for other strings of animal origin, as well as for animal ligatures in general. Mr. Lister has elucidated this whole subject most thoroughly by observation and experiment, and, without doubt, the catgut prepared on his plan is superior to all other kinds of ligature in use to-day. If the catgut receive no special preparation whatever before using it, there is always a risk that it may prematurely soften in the warm plasma with which it becomes soaked when placed around bloodvessels in wounds, in which case the knot may slip or untie, or the catgut itself may be absorbed before the occlusion is complete—and thus it would fail to accomplish the purpose for which, as a ligature, it was applied. The method of preparation which Mr. Lister has found, after various trials, to be that which may be recommended is the following: Take one part of chromic acid, four thousand parts of distilled water, and two hundred parts of pure carbolic acid or absolute phenol. In other words, make a one-to-twenty solution of carbolic acid, not in water alone, but in an exceedingly dilute solution of chromic acid. This small quantity of chromic acid will have a very great effect upon the catgut. In the chromo-carbolic solution place an amount of catgut about equal in weight to that of the carbolic acid employed. If there is too large a proportion of catgut, it will not be sufficiently prepared; if there is too small a quantity it may become over-prepared. At the end of forty-eight hours, catgut steeped in such a solution is sufficiently prepared. It should then be taken out and, after drying, be placed in one-to-five carbolic oil. It is now fit for use. It must, however, still be kept in the mixture of carbolic acid and sweet oil (one part to five), in order that it may remain unchanged and not become over-prepared, and that its antiseptic condition may continue to be assured. The advantages of catgut, when treated in this way, for use as ligatures, are: (1) it is antiseptic; (2) a knot will hold with perfect security, and the noose will not prematurely dissolve in the plasma, nor disappear until it is replaced by a ring of fibrous tissue, and until the occlusion is perfectly safe; (3) the knot and noose will not prove too durable, that is, they will not be found to be insoluble and incapable of being absorbed at the right time; for if they should prove too durable they would work their way out by ulceration, like corresponding bits of carbolized silk or hempen thread. The spontaneous disappearance of catgut ligatures when set in wounds, is caused, not by any chemical solution of their structure, nor by any process of organization which they undergo, but by the invasion of leucocytes, under the operation of which they vanish, while new tissue takes their place; but, if they be over-prepared, this change does not occur, and they act like foreign bodies in general.

In applying the ligatures of prepared catgut, they should generally be drawn with sufficient force to divide the inner and middle coats of the artery; they should also be tied with a reef or square knot, and both ends should be cut off close to the knot. Doubtless, the tube of an artery may in many, per-

[1] Op. cit. p. 27.

haps in most, instances be obliterated by this ligature when the inner and middle coats are not divided by it. Indeed, Professor Jameson, of Baltimore, showed, more than fifty years ago, that the buckskin ligatures which he employed obliterated the arteries without cutting their inner and middle coats, and without destroying their continuity. Hence he opposed all indissoluble ligatures of whatever material; he declared it to be not only unnecessary but highly hazardous to cut the inner and middle coats of arteries, as recommended by Jones, etc.; and he agreed with Scarpa in regard to flat ligatures; but, by using buckskin, he had no need, like Scarpa, to remove his ligatures on the fourth day. Experience, however, has abundantly shown that the round is, for most cases, the best form for animal as well as for other ligatures; and that, in general, it is best to divide the inner and middle coats of arteries when applying them. Obviously the hæmostatic effect of animal ligatures is much increased by this proceeding, while the hazard is not increased in anything like the same proportion, especially if the wound be treated antiseptically.

Besides those mentioned above, other strings of animal origin have been successfully employed for ligating bloodvessels. Mr. Barwell has provided for that purpose narrow strips of the mingled yellow-elastic and unstriped muscular tissues which constitute the arterial wall, obtained by spirally cutting the aorta of the ox. Mr. Sterling has brought ligatures made of kangaroo tendon from Australia. Dr. Ishigouro, of the imperial Japanese army, has devised a ligature of whale tendon, which by some surgeons is strongly recommended. Dr. Wyeth has employed the sciatic nerve of a calf. Catgut, however, has some advantages which the others do not possess. It is to be had in abundance all over the world; it is strong and beautifully smooth; it is supplied of various sizes, admirably adapted for all the purposes of the surgeon; it is extremely cheap, and is easily prepared for use by the method described above. The only precautions to be observed in employing catgut for ligatures are: (1) to select that which is properly prepared for the purpose, as well as sufficiently strong; (2) to draw it between the thumb and index finger in order to free it from all excess of the carbolized oil in which it has been laid; (3) to adjust the knot with care; and (4) to leave the ends about one-fourth of an inch in length.

Metallic Ligatures.—The excellent results obtained by Sims, Emmet, and others, from the use of metallic sutures in operating for vesico-vaginal fistulæ, seemed to justify a belief that metallic threads—for instance, those made of silver, lead, or iron—really caused less irritation when applied, in wounds, than threads made of flax, hemp, etc.; and this belief was apparently confirmed by Simpson's experiments. Moreover, Ollier from observation and experiment was led to attribute to metallic threads the following advantages:—(1) They ulcerate and divide the tissues less rapidly; (2) they occasion less suppuration along their track; (3) they are sooner tolerated by the tissues through which they penetrate, and may be allowed to remain for a longer period; (4) they leave smaller cicatrices; and (5) these advantages are all due to the lower degree of irritation which attends their use. Ollier's experiments clearly showed the value of *fineness* in the metallic thread or wire; when wire having the thickness of a hair of the beard was compared, by its effects, with the thread commonly employed, the superiority of the former was undeniable. When the threads were of the same size the difference was less sensible; and, occasionally, for some days it could not be perceived. As a rule, however, threads made of metal had the superiority of finally becoming tolerated (that is, healed in, like ear-rings), whilst those of vegetable origin continued to excite suppuration. He found iron wire to be

as well tolerated as wire of any other metal; and, inasmuch as it could be produced of extreme fineness without being too much weakened, he used it exclusively in the end.[1] Thus, the employment of metallic sutures soon became popular among surgeons.

The non-absorbent and non-irritating character of metallic threads, as shown by their use for sutures in dressing wounds, naturally suggested to surgeons their employment for ligatures in tying arteries. Accordingly, Dr. Stone, of New Orleans, ligated the common iliac artery with a silver wire, in 1859. Since that time, Professor Gross has ligated the femoral, and Professor Agnew the brachial artery with the same sort of metallic thread. In 1866, Dr. C. H. Mastin, of Mobile, tied the external iliac with the same material. In applying the metallic, as well as the animal, ligature, both ends are cut off near the knot. The final disposition of the loop, however, is quite different in these cases. The portion of an animal ligature that is left in the wound is expected to become soft, infiltrated with leucocytes, and in the end entirely absorbed, as stated above; while the best that we can hope for a metallic loop, is that it will become imbedded in a deposit of organizable lymph.

Appreciation of the Different Ligatures.—The "*flaxen thread*" of Avicenna, and *the hempen thread* of recent times, are admirably adapted in respect to form, size, and strength, for the ligation of bloodvessels. But opposed to these good qualities is the fact that these threads are liable to cause much irritation by their presence in wounds, not only because they are foreign bodies, but also because a peculiar fermentation of an acid nature may occur, which has in them its starting point and seat. For example, Mr. Lister, in operating for goitre, used six hempen ligatures carefully rendered antiseptic by means of the carbolic lotion. During the first eight days everything went on in typical fashion according to the antiseptic method. On the ninth day, however, some pus was observed mingled with the discharge. The purulence increased, and in a month one of the hempen ligatures made its escape. In six days more, four others came away, altogether unaltered in appearance. They were submitted to careful examination. They had a sour odor, and, applied to litmus paper, gave an acid reaction; that is, the natural alkaline reaction of blood-serum had been changed to acidity by a peculiar fermentation, differing from putrefaction, which would, if possible, have made the blood-serum still more alkaline. Under the microscope, the interstices of the threads were found loaded with little organisms to which Mr. Lister gave the name of *granuligera*, occurring in groups of twos, threes, and fours, etc., quite distinct from the chains in which ordinary bacteria occur. These micrococci, developing in great abundance in the interstices of the hempen ligatures, produced an acid fermentation of the serum in its most aggravated form. The acid serum caused irritation, and thus the carbolized ligatures which, otherwise, might have become encapsuled, gave rise to suppuration. The remaining ligature was ultimately discharged, unaltered in appearance, in the same manner.[2] Here, then, we have an illustration of the great disadvantages which may arise, even under antiseptic treatment, from the use of hempen and other ligatures made of vegetable fibres.

*Carbolized Silk* (that is, uncolored silk which has lain for half an hour in a mixture of melted wax and carbolic acid) is not, in my opinion, open to this particular objection for use in the ligation of bloodvessels. G. Simon, as the result of many experiments, did not perceive any important difference be-

[1] Gaz. Hebd., 1862, pp. 135, 181, 261, 359.
[2] Med. Times and Gaz., Feb. 5, 1881.

tween fine well-twisted silk, and fine metallic threads, for sutures in vesico-vaginal fistulæ.[1] The advantages of carbolized silk are that it is antiseptic, strong and smooth, easily obtained, easily applied, and easily removed. Its disadvantages are that it is a foreign body, and that it finds its way through the arterial tissues by ulceration.

*Metallic Ligatures*, by reason of their non-absorbent properties and their inability to become soaked with decomposing discharges, possess a special advantage. But they cannot always be applied with ease; and for the purposes of general ligation they are certainly not well adapted. It remains, however, for future experience to determine what their true value is for ligating large arteries in their continuity, such as the iliacs, the femoral, brachial, etc. But it seems at present quite probable that, like other non-irritating ligatures of a permanent character, they will, for the most part, find their way out by ulceration, and therefore will be attended with the dangers peculiar to that process, just the same as ligatures of carbolized silk. Indeed, I have no doubt that, *for general purposes*, carbolized silken thread is preferable to every other kind of *permanent* ligature in use for tying arteries.

*Animal Ligatures*, that is, the ligatures made of buckskin, deer sinew, catgut, kangaroo sinew, whale tendon, and ox aorta are, in their nature, not permanent, and they possess, when properly prepared, a great superiority over all other ligatures whatever, inasmuch as they do not act as foreign bodies in the wounds where they are placed. They lie there harmless and unirritating, in contact with the tissues, and, becoming infiltrated with leucocytes, are, in due time, entirely removed by absorption; new fibrous bands or rings, however, taking their place. The tendency of some of these ligatures to soften prematurely, and of their knots to slip or become untied, whereby their hold upon the wounded vessel might be loosened before the proper time, was formerly an objection to their use in tying large arteries; but this objection is no longer valid, for the material can now be treated in such a manner as to make the knot entirely safe, and, at the same time, impart greater flexibility as well as strength to the thread itself. For the general purposes of ligation, I believe that carbolized catgut, prepared on Mr. Lister's plan, described above, is superior to every other kind of ligature; and the soundness of this belief is attested by the experience of surgeons in every part of the globe, as well as by considerations which I have already adduced. In short, the catgut thus carbolized is a non-irritating ligature which seems to fulfil all the conditions of a perfect hæmostatic, combining the security and universal applicability of the ligature, with absence of the bad effects of a foreign body in the wound. After the knot is tied, both ends of this ligature should be cut off, and the wound permanently closed.

## IV. Torsion.

Twisting the cut ends of arteries was distinctly recognized by Galen as an important means for restraining the flow of blood therefrom. Aëtius, Paulus Ægineta, and Rhazes also recognized torsion as a hæmostatic measure of importance. Subsequently it became obsolete. In 1829, Amussat revived its use by proving from experiments on animals that it was a safe and efficient means of stanching hemorrhage from many wounded arteries. Soon afterward Thierry followed to the same effect. Velpeau, however, first employed torsion on the human subject. In the same year Liber, Fricke, Dieffenbach,

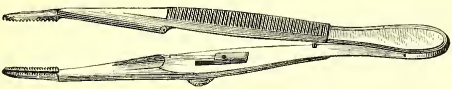
[1] New Syd. Soc. Year-Book, 1862, p. 181.

and others, made numerous trials thereof in Germany, seemingly with entire success. The French surgeons, Louis and Delpech, met with several failures. The subject was deemed of such importance by the Institute of France as to require a thorough examination, and, accordingly, it was referred to Baron Dupuytren. His report was unfavorable to the method, except in its application to small arteries. Then torsion went out of use again, to be revived once more, however, by the late Professor Syme. During late years it has met with great favor at Guy's Hospital, London, from Mr. Bryant and others; but in America it has not been received with much favor, though at the Pennsylvania Hospital, Philadelphia, Dr. Hewson used it with success.

The torsion of arteries for suppressing hemorrhage may be practised in various ways. Amussat recommended that the artery should be drawn out about half an inch by one pair of forceps; that it should then be seized by another pair of forceps, and the end twisted off by about half-a-dozen turns. Fricke advised that the end should not be taken off, but merely twisted around six or eight times, according to the size of the vessel. Thierry simply seized the artery by its end and twisted it. Doubtless, hemorrhage from very large vessels may be permanently suppressed by torsion, the artery being placed thereby in a lacerated condition. The inner and middle coats are retracted, and the outer one is twisted into a kind of valve, which covers them. A coagulum next forms within the tube, blocking up its extremity; inflammation then occurs, gluing together the lacerated coats of the vessel; the twisted end sloughs off, and the tube becomes permanently occluded up to the nearest branch.

Two methods of twisting the ends of divided arteries, so as to arrest the bleeding, are now in vogue. The first is substantially that of Thierry. To

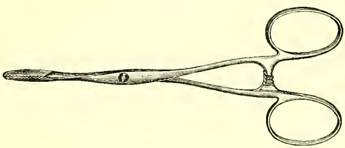
Fig. 391.



Slide-catch artery torsion and needle forceps.

perform his operation strong forceps, having serrations which are not sharp enough to cut the artery, are required. (Fig. 391 or Fig. 392.) The end of

Fig. 392.



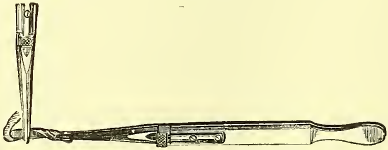
Professor Wood's artery forceps.

the artery being seized, it should be drawn well out into view, and the forceps should be merely rotated until all resistance ceases, but not to the extent of twisting off the end of the vessel. This operation is also called that of *free* torsion.

The second method is that of Amussat. (Fig. 393.) According to this author, the artery should be taken hold of and drawn out five or six lines from the surface of the wound by forceps of suitable breadth, and furnished

with a slide-catch for fastening the blades together when closed; the vessel must then be separated from the surrounding parts with other forceps, or with a small knife, until it becomes entirely isolated. Next, the artery must be seized with the second forceps, or with the fingers of the left hand, at the point where it emerges from the surrounding soft parts, and held firmly fixed.

Fig. 393.

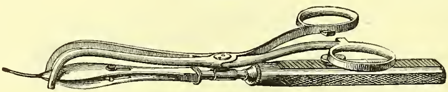


Showing Amussat's plan of making torsion.

The artery is then to be turned round on its own axis, or twisted with the first forceps, until the end is torn off, when the bleeding will be certainly stopped. Below the fixed part no blood is found in the tube of the artery. If no forceps be at hand, the artery, in urgent cases, may, as was proposed by Galen, be pierced with a needle or with a nail, and so twisted round. Torsion performed by this method is called *limited* torsion.

A very ingenious instrument for the torsion of arteries has been devised by Dr. Addinell Hewson (Fig. 394), which combines, in one, the two forceps employed by Amussat and others.

Fig. 394.



Hewson's artery torsion forceps.

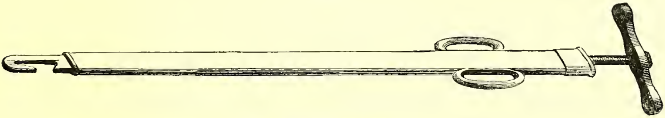
The advantages claimed for torsion are the following: (1) The facility with which it can be performed. In reply, I may say that I have seen as much time consumed in twisting an articular branch in the arm, before the bleeding could be stayed (and that, too, by one entirely familiar with the work), as would have sufficed for an amputation and all the subsequent dressings by the old method; and, further, that I have seen it fail altogether in more than one instance, compelling a resort to the ligature before the rebellious artery could be secured. The use of anæsthetics has, moreover, in great measure, removed the necessity for excessive haste in operating. (2) Greater safety is claimed for torsion. I am not aware that we possess the means for making any extended comparisons between this and other methods, but my own observation furnishes instances in which secondary hemorrhage followed torsion even of sound vessels, a circumstance which is, I think, rarely met with after ligation. (3) It is said that by torsion the healing is facilitated, because of the wound's being free from all irritating or foreign bodies. Yet the end of the twisted artery, comminuted and bruised, frequently separates as a slough, and becomes as much a foreign body as a ligature. The experience of both Velpeau and Manec shows not only this, but also that the healing after torsion is as slow as the healing after the ligature; indeed, according to the authority last named, it is even more tedious (Agnew). That large arteries, such as the femoral, brachial, etc., have been safely treated by torsion, is no doubt true;

that secondary hemorrhage has followed torsion, and life been sacrificed, is, however, equally true; and I am not prepared to admit that torsion possesses any superiority over the ligature of carbolized catgut; indeed, I do not believe that torsion equals it for general use as a hæmostatic measure.[1]

## V. Constriction or Crushing of Arteries for the Arrest of Hemorrhage.

Dr. S. Fleet Speir, Surgeon to the Brooklyn City Hospital, has devised an instrument for the instantaneous hermetical closure of arteries without the use of ligatures or other foreign substances to be left in the wound, which he calls the "artery constrictor." (Fig. 395.) Professor Hamilton and others speak highly of it from experience.

Fig. 395.



Speir's artery constrictor.

This instrument consists of a flattened metal tube, six inches (more or less) in length, open at both ends, with a sliding steel tongue running its entire length, and having a vise-like arrangement at the upper end by which the tongue may be protruded from or retracted within the tube or sheath. The lower end of the tongue is hook-shaped, so as to be adapted to the artery to be constricted. It is so shaped that, having grasped the artery, it can be made to contract upon it by means of the vise at the upper end, which draws the tongue into the sheath.

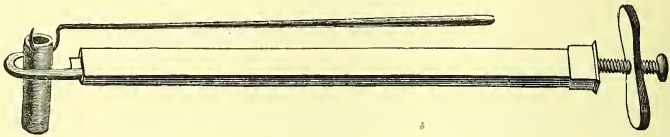
The hook of the tongue is so shaped and grooved as to form only a compressing surface, by means of which the artery, when acted upon by the force of the vise, is compelled to assume the form of the curve of the tongue, and the artery is constricted in such a way that the inner and middle coats give way, but the external coat is preserved intact. The severed inner and middle coats retract, curl upon themselves, and are driven down the artery, in the form of an invagination or plug, by the continued pressure of the grooved tongue as it passes into its sheath. The artery may now be slipped out of the instrument, and it will be found that the external coat has been compressed at the point where it was in contact with the instrument, and the inner and middle coats will be divided and invaginated on either side of the constriction. (Figs. 399, 400.) This invagination of the inner and middle coats is of itself sufficient to check the flow of blood. As soon as the current of blood is arrested in the tube, a coagulum forms upon the invaginated inner and middle coats, and this completes the occlusion. (Figs. 400, 401, 402.)

The application of the constrictor is very simple. The artery is to be caught up by a tenaculum (Fig. 396), or by forceps (the latter is preferable), and the tongue of the constrictor placed around the vessel; the tongue is then drawn tightly upon the artery by means of the vise-like arrangement

[1] In regard to the employment of torsion for the arrest of hemorrhage, Professor Esmarch (Surgeon's Handbook, p. 185) says: "If there be no antiseptic material at hand for ligatures, the arteries may be closed by torsion;" and I am fully convinced that this is the only contingency which renders the use of torsion advisable.

at the upper end of the instrument. As soon as the screw turns with a considerable degree of resistance, or the inner and middle coats are seen to be sufficiently invaginated, by observing their movements in the open end of the

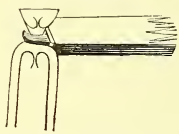
Fig. 396.



Showing how the artery is placed within the grasp of the constrictor.

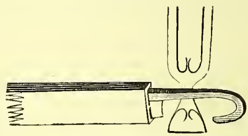
artery, the instrument is to be detached from the artery, and the operation is completed. The length of time required for the operation is about one minute, or more, according to the size of the artery.

Fig. 397.



The constrictor applied and closed

Fig. 398.



The constrictor in the course of removal.

Fig. 399.

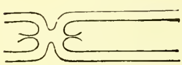
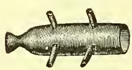


Diagram showing the first effects of constriction.

Fig. 400.

The coagulum.

Fig. 401.



Showing the external appearance of the constricted artery.

Fig. 402.

Showing the effects of constriction applied in the continuity of an artery.

Professor Hamilton says that, in the experiments on the cadaver which he has made with Dr. Speir's instrument, he has always found the inner and middle coats of the artery invaginated or recurved enough to completely close the channel, and likewise to resist the flow of water forced in by a Davidson's syringe. In operating on large arteries, the tongue of the constrictor must be drawn into the sheath further than is required in operating on small arteries. This is the one point necessary, and to be attended to, in constricting large arteries, namely: a perfect invagination of the inner and middle coats must be secured. This invagination may be made as complete as may be desired, by drawing the artery up into the tube with the hook which grasps it, as far as may be needed to effect the object. The instrument may be made with a stop to indicate when a sufficient invagination has been reached; but experience has shown the *touch* to be the best guide for the

operation. By a continued traction, made through the constrictor upon the outer coat of an artery, after the invagination is once commenced, the inner and middle coats may be peeled up and pushed entirely out of the external coat, and thus the latter may be drawn through the sheath of the instrument, freed entirely from the other tunics; wherefore, the operator has it in his power to make the invagination as extensive as he may wish; and, if he always takes care to make the invagination perfect, failure in using the instrument will be impossible. In amputations, etc., it is always advisable to loosen the tourniquet and allow the blood to flow into the main artery before removing the constrictor, for thus will be secured upon the invaginated tunics a perfect clot, which, afterwards, can hardly be displaced.

Professor Hamilton also says that the experiments which have been made with Dr. Speir's constrictor, under his own observation, induce him to believe that it will, at least, prove superior to acupressure and torsion; and that it is quite competent to close hermetically the femoral artery and other vessels of the same class, after amputations, etc. But, time enough has not elapsed since the introduction of the instrument, in 1871, to enable us to decide as to its merits by the test of experience. A further judgment must therefore be reserved for more extended observation.

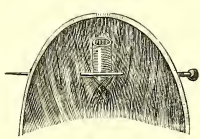
For convenience, the constrictor may be made with three sizes of tongues, to be used with one tube, so as to fit more nearly the cylinders of different arteries. Furthermore, Professor Hamilton advises those who use Dr. Speir's constrictor to order it from his instrument maker, or to copy it with great care from the original, and not to attempt to construct it from any description, since, upon the fashioning of the hooks, the value of the instrument in great measure depends.

## VI. Acupressure.

In December, 1859, this method of hæmostasis was first presented to the world by the late Sir James Y. Simpson, in a communication to the Royal Medico-Chirurgical Society of Edinburgh. The instruments required for operating on this plan are very few and simple. They are (1) bayonet-pointed pins, varying in length from three to five inches, with glass or wax heads to facilitate their introduction, (2) needles threaded with fine iron wire, and (3) loops of slender iron wire, well annealed, and five or six inches in length. On the cut surfaces of flaps the ordinary sewing-needle answers perfectly well. There are several methods of employing the pins in order to exert on the wounded artery the compression which is desired; but, practically, they may be reduced to three.

1. Direct Compression (Fig. 403) is made by a pin thrust through the flap, passed over the artery, thrust into the flap again, and brought out of it on the side opposite to the point of entrance, in such a manner as to firmly compress the end of the severed artery against the muscle on which it lies; in other words, the wounded artery is secured on the face of the stump by inserting a pin, as one would secure the stem of a rose on the lapel of his coat.

Fig. 403.



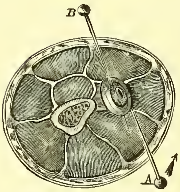
Acupressure by the first method.

2. Compression with Wire is effected by passing the point of the pin or needle under the vessel, then casting over it and in front of the artery

a loop of iron wire which is to be tightly fastened to the shaft of the pin or needle; the pin is then to be passed through the opposite flap. A good plan for using the wire is to place a loop of it under the point of the pin or needle already inserted, carry both ends of the loop across in front of the artery, then pass one of them beneath the head of the pin or needle, and, finally, fasten the two ends together by twisting them as tightly as may be desired.

3. COMPRESSION BY TORSION (Fig. 404) is made by transfixing with a pin the face of the wound or stump, an inch or more on the side of the artery at *A*, then carrying the head of the pin half-way around the face of the stump or wound to *B*, and there thrusting the point of the pin into the tissues beyond, so as to hold it securely. The pins or needles should not be left in more than forty-eight hours for the larger, and twenty-four hours for the smaller arteries; and even a much less period has been found sufficient to obtain permanent occlusion.

Fig. 404.




Acupressure by torsion.

To these methods should be added that of the late Dr. Buck, of New York, which consists of torsion combined with transfixion. In applying it, the artery is first seized with a torsion forceps (Fig. 391) and twisted around on its axis two or three times, when the pin is to be thrust transversely through the cylinder of the artery, and then fixed in the surrounding tissues.

Mr. Bryant remarked, at a recent meeting of the Royal Medical and Chirurgical Society,[1] that "acupressure had been almost abandoned, because, in the case of severed arteries, it was frequently followed by secondary hemorrhage, the vessel not being occluded long enough to allow of permanent clotting." Professor Esmarch makes no mention whatever of acupressure in his Surgeon's Handbook; and I think that he is quite right, because, though historically of importance, it is not of much practical value as a hæmostatic measure.

## VII. AËRTERIVERSION.

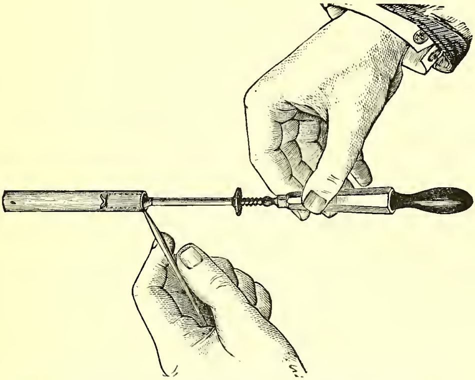
Dr. G. C. E. Weber, of the Medical Department of the University of Wooster, at Cleveland, Ohio, proposes to constrict the mouths of arteries divided in amputations, by turning over their ends with a little instrument, called an aërteriverter by Dr. Weber, but quite similar to the fine double hooks, operated by a sheath, the invention of M. Lüer, of Paris, and called by him *fixateur à gaine*. With this instrument the ends of divided arteries may be retroverted, as one turns over the cuffs of his coat in rolling up the sleeves. This method is designed to reinforce the cut extremity of an artery by the duplicature of its walls, thus surrounding its open mouth with such a quantity of arterial muscular and elastic fibres as to effectually close it against the impulse of the heart's action.

The operation is easily performed by introducing the hook-end of the instrument into the artery up to the point where the reflexure of its walls is to be made, and there planting the hooks in the inner and middle coats; then by grasping the end of the artery with forceps, held in the other hand, and slipping the section of the vessel embraced between the two instruments

[1] Lancet, March 26, 1881.

over the first, on the hooks as over a fixed point (Figs. 405 and 406), the inversion of this part of the artery is readily secured. After the retrover-

Fig. 405.



Showing the aërteriverter introduced up to the point where the artery is to be turned over, with the double-hook extending a little beyond it.

sion is effected, there always remains a strong tendency for the vessel to unroll itself again, due to the pulsatory movements of the artery itself; this may

Fig. 406.

Showing the appearance of the artery when the inversion is just completed, prior to the removal of the instrument

be met by inserting a fine, smooth, steel peg, made of the end of a number twelve English sewing-needle. (Fig. 407.)

Fig. 407.

Showing the retroverted part of the artery fastened with a delicate little peg, prepared by breaking off the end of a fine sewing-needle. The peg, when allowed to remain, apparently does no harm.

Dr. Weber has operated by this method with success on the femoral, the brachial, and the anterior and posterior tibial arteries, in amputations of the thigh, arm, and leg.[1] He claims, from his own experience, that this method of treating arteries is a justifiable proceeding, and that it possesses a decided advantage in leaving scarcely anything but living tissues in the wound. The value of this operation, however, is not yet determined.

[1] Medical Record, pp. 308–310. New York, 1875.

## VIII. Cauterization.

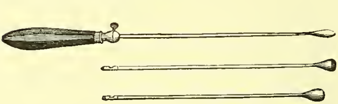
The application of a *hot iron* is one of the most ancient means of arresting hemorrhage. It acts mechanically by forming, out of the charred tissues, a plug, which restrains the outflow of blood. It is by no means an obsolete method of procuring hæmostasis. Boyer relates an instructive example:—

A servant was playing on a Jew's-harp; some one gave him a blow which drove the instrument into his mouth; the blood flowed; a surgeon was called, who directed astringent gargles; they did not answer; he next stuffed the mouth with lint, and bandaged the upper and lower jaws together, but to no purpose; the bleeding continued for twenty-four hours, and the patient was almost exhausted, when Brasdor, a professor in the ancient school of surgery, who related the case, was called in. His first care was to see where the blood came from. He emptied the patient's mouth, and washed it clean. He saw the hemorrhage proceeding from the inferior and anterior part of the tongue; he heated an iron slyly, and put it on the place whence the blood flowed; an eschar was formed, the bleeding stopped in an instant, and the patient got well.[1]

In this case the ranine artery was wounded; a ligature could not be applied, owing to the inaccessibility of the lesion, and compression was impracticable from the softness and mobility of the tongue. In all similar cases of hemorrhage from the mouth or throat, the actual cautery furnishes the best means of arresting it. The cautery, too, is often employed with success to stop the flow of blood from small, deep-seated vessels lying beyond the reach of the ligature; also where there is free oozing from numerous points, such as occasionally follows operations on the maxillary bones, operations for the removal of piles, and sometimes excisions of the tonsils.

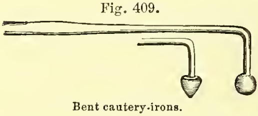
The *cautery-iron* consists of a knob of that metal at the end of a long shaft, fastened to a convenient handle. The shape of its extremity may be globular, or olivary, or button-like, etc., each form being adapted to some special

Fig. 408.



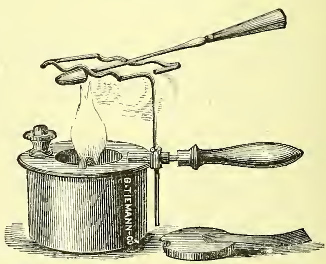
Straight cautery-irons.

Fig. 409.



Bent cautery-irons.

Fig. 410.



Blowpipe for heating the cautery-irons.

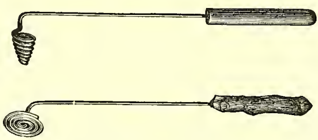
condition requiring its use. (Figs. 408, 409.) It may be heated in the flame of a common spirit-lamp, or in that of a blowpipe made for the purpose. (Fig. 410.)

Cautery-irons may be extemporized from stove-pokers, knife-blades,

[1] Traité des Maladies Chirurgicales, t. i.

knitting-needles, iron-wires, etc. They may easily be extemporized from pieces of telegraph wire by rolling up one end into a spiral form, filing the other end to a point, and pushing it into a piece of wood to serve as a handle. (Fig. 411.)

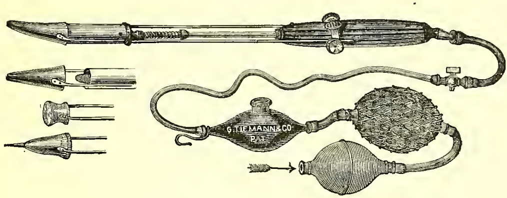
Fig. 411.



Cautery-irons improvised from telegraph wire, after Brandis. (Esmarch.)

In applying the cautery for hemorrhage, care must be taken that the iron is heated only to a dull red color; for, should it be raised to a bright red or white heat, it may defeat its own purpose by destroying the artery too extensively, or by bringing away the eschar stuck fast to the iron, thus leaving the vessel unclosed. When practicable, the heated iron should be passed through a glass tube down to the bleeding orifice, in order to shield the surrounding parts from injury. The late Dr. George McClellan, of Philadelphia, in this way, introduced red hot wires of the largest size down the throat and up the nostrils, to check the hemorrhage from bleeding vascular tumors, with perfect safety.

Fig. 412.



Tiemann's thermo-cautery apparatus.

The *thermo-cautery instrument* is a very ingenious and useful contrivance, introduced by Paquelin, by which the *cauterizer* or platinum point may very quickly be raised to a bright red or even a white heat, and may have the same degree of heat kept up for any length of time without any difficulty whatever. It is peculiarly well adapted for operative procedures in the mouth, vagina, and rectum. By attaching a blade to it, incisions that are bloodless may be made, and with an écraseur of platinum wire, tumors may be removed in a bloodless manner also.

In preparing the instrument for use (Fig. 412), the button-screw cap is to be removed from the receiver, and benzine or gasoline is to be poured into it until the wool which it contains is saturated with the liquid, but no more than that. On replacing the cap, the receiver itself may be suspended from a button-hole by means of the hook which projects from one end of it. By working the elastic bulb or pump at the lower end of the instrument, air is forced into the receiver in a steady stream, where it becomes saturated with benzine or gasoline; thence the mixed gases are forced upward through the platinum cone at the upper end of the instrument, into the platinum point, No. 1, which is attached to it. Ignition may be started with a match. The degree of heat is adjusted to that which is required, from dull red to white, by drawing the platinum cone down upon the cylinder. A stopcock regu-

lates the volume of mixed gases to be passed. Platinum points of various patterns, *e. g.*, knife-shaped, No. 2, flat, No. 3, and needle-pointed, No. 4, are easily attached.

### Appreciation of the Various Hæmostatics.

Most of the agents employed by surgeons for the suppression of hemorrhage, have been so thoroughly discussed in the foregoing pages, that but little remains to be said concerning their relative value or importance. *Cold* is unquestionably a most valuable, as well as an ancient and safe, means of arresting hemorrhage. Fresh cold air and carbolized iced water (one part to one hundred) afford the most convenient and useful forms for applying it. The latter may be squeezed out of a sponge in a shower, or squirted from a syringe in a small stream, upon the bleeding surface. [*Hot* water is often of value in arresting capillary hemorrhage.] Among styptics, the best are *alcohol* and the *oil of turpentine;* the latter to be applied directly to the bleeding apertures on dossils of lint. Persulphate and perchloride of iron are peculiarly objectionable, inasmuch as their use is attended with the formation of hard, insoluble coagula, which are removed with great difficulty, and which, if allowed to remain, interfere very much with the dressing and healing of deep wounds, and with the performance of any surgical operations that may afterward be needed. The ferric salts should be restricted in their use as styptics to leech-bites, to parenchymatous hemorrhages, and to superficial injuries.

*Compression*, both as a temporary expedient and as an adjuvant to other measures for arresting hemorrhage, is of extreme utility. The value of digital compression as a temporary hæmostatic when large vessels are wounded—especially when promptly, that is, seasonably applied, cannot be over-estimated. Compression by tourniquets is indispensable. The elastic bandage and tubing, or ligature, of Esmarch, afford, also, a most excellent means of applying pressure for the temporary arrest of hemorrhage, in a wide range of cases. Tampons, too, in some wounds are absolutely necessary.

Neither *acupressure* nor *torsion* affords anything like the same security that attends the application of ligatures to wounded bloodvessels. *Constriction*, by Dr. Speir's instrument, is superior to both torsion and acupressure, because with it the lumen of the artery can certainly be filled up by the incurvations of the divided inner and middle coats. The success of *aërteriversion* is not yet assured.

*Ligation* affords the greatest security that is possible against the return of hemorrhage, provided it be made with threads of animal origin which have been properly prepared for the purpose; for instance, with ligatures of catgut prepared by Mr. Lister's method. The grounds on which rest the superiority of animal ligatures in general, and that of the prepared catgut ligatures of Mr. Lister in particular, over all others, have already been set forth; it is not necessary to recur to them in this place.

The *actual cautery* is indispensable for suppressing hemorrhage from small deeply-seated arteries, so placed that they cannot be tied or compressed; for example, in the mouth, the fauces, the nares, the rectum, etc.; and from parts which, by reason of weakening or disintegration, will not hold a ligature.

### Internal Hæmostatics.

There are a few remedies which may assist not a little in suppressing hemorrhage, when administered internally, provided that the bleeding vessels are

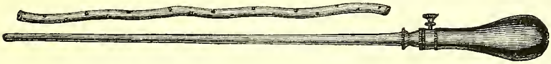
small, like those of the nostrils, uterine cavity, pulmonary cavity, etc. The most important of these remedies are, (1) oil of turpentine, given in doses of ten drops suspended in mucilage or simple emulsion, every fifteen or twenty minutes; (2) fluid extract of ergot, twenty or thirty drops every half hour; (3) gallic acid, ten grains every hour; (4) aromatic sulphuric acid, fifteen drops every two hours, mixed in water; (5) opium, given in doses sufficient to allay restlessness and mental anxiety—a most valuable remedy against hemorrhage; and (6) acetate of lead, in doses of not less than two grains every hour or two, combined with opium, a combination which has sometimes suppressed hemorrhage after everything else has failed.

## After-treatment of Hemorrhage.

After the bleeding is stanched, everything which could bring it on again must be carefully avoided. To that end the patient himself, as well as the injured part, must be kept at perfect rest. In cases where the bleeding has been stopped mainly by applying pressure, it oftentimes is advisable to continue to compress the main trunk of the artery on the cardiac side of the wound, as well as the wounded vessel itself at the place of injury, until the period of reaction is fully passed, and perhaps even longer than that, lest the occluding coagula should be driven out by the increasing force of the blood-stream.

The surgeon must also provide against the return of hemorrhage by causing, if possible, union of the wound throughout to occur by the first intention, with correspondingly speedy healing of the vascular lesion itself. He will, therefore, employ antiseptic dressings and the antiseptic plan of treatment, and do whatever else seems requisite to fulfil this indication. But when, owing to the nature of the injury, there will be suppuration—as, for instance, usually happens in gunshot and contused wounds—he must seek to prevent the recurrence of hemorrhage by providing for the immediate discharge of matter by means of drainage-tubes inserted in the wound (Fig. 413), and by the em-

Fig. 413.



Chassaignac's drainage tnbe and drainage trocar.

ployment of "through drainage" also, whenever practicable. If the wound become inflamed, he must promptly abate the inflammation by applying an ice-poultice, or iced-water irrigation, or an ice-bag to the inflamed part; and by administering cooling drinks, with a bland diet. He must protect the patient from constitutional infection by the absolute cleanliness as well as the antiseptic quality of the dressings, by the freshness and purity of the air he breathes, and by the nourishing, sustaining, or healing quality of the food he eats. In all wounds implicating large bloodvessels, where sloughs must be discharged, the surgeon must have a close watch kept by the attendants on the patient, so as not to be taken unawares by the occurrence of secondary hemorrhage; and they must be instructed beforehand what to do pending his arrival. Especially must the surgeon take care to prevent the burrowing of purulent matter in these cases, and the occurrence of inflammation in the perivascular tissues, by prompt incisions, by complete drainage, by thorough antisepsis, and by judi-

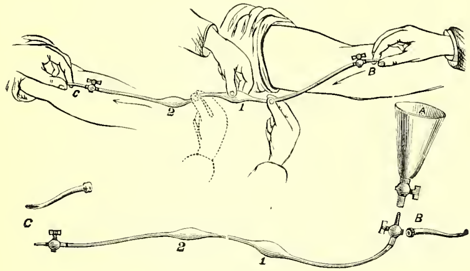
ciously employing the antiphlogistics mentioned above, when union by the first intention cannot be obtained.

When, however, the loss of blood has been very great, or the patient has barely escaped with his life, and lies very low in consequence of it, something quite different must be done. In the first place, great pains must be taken to avoid the occurrence of a fresh syncope, for, with the highly anæmic condition of the brain already existing, it might readily prove fatal. His head must, therefore, be kept in a depressed position, in order to make the blood gravitate toward his brain from the other parts of his body. His head must not even be raised for the brief moment of time required to slake his thirst, which is apt to be intense; but drink must be freely given him through a bent tube, or from an "invalid's cup," long ago devised for the purpose, while his head remains low or depressed. The arms and legs of the patient must not be allowed to hang down from the couch on which he lies, because the blood would gravitate into them away from the brain, and thus the cerebral anæmia would be increased. On the contrary, the limbs may be raised up with advantage, and likewise be tightly bandaged from fingers and toes to trunk, in order to lessen the area of the circulation as much as possible, and thus secure more blood for the brain. The drink should consist of lukewarm milk, to which a little good wine or brandy is added, and should be given with a view to rapidly replenish the empty bloodvessels; and, as soon as it can be prepared, freshly made beef-tea should also be given. But the quantity and the effects of the alcoholic stimulants are to be closely watched, lest harm be done by their unrestricted use. The fumes of strong liquor ammoniæ should be applied to the nostrils in order to increase the frequency and depth of the respiratory movements. Fresh, cool air should be freely admitted to the patient; but, at the same time, the coldness of his body should be combated by the application of dry heat. During the convalescence from exhausting hemorrhages, tincture of the ferric chloride, good wine, and a generous diet are chiefly the means by which the anæmia, the debility, the cardiac palpitations, and the nervous irritability are to be overcome. In many cases, however, something further still is required from the surgeon; and that something is the operation of transfusion, performed in order to save life. This operation may be defined to be the injection of the blood of one person into the bloodvessels of another, for the purpose of summarily effecting the relief of extreme exhaustion.

Transfusion.—In many instances that occurred during the late civil war, great losses of blood, from wounds which did not kill at the time, were followed by a state of anæmia and general debility from which the patient could not be raised by even the most assiduous employment of the most nutritious kinds of food and of the choicest forms of alcoholic stimulants, with the chloride of iron, or the citrate of iron and quinine; and the consequence was that such patients perished miserably from anæmic exhaustion some considerable number of days after the bleeding had been arrested. The correctness of this statement is attested by numerous cases related in the Medical and Surgical History of the War. Now, in looking back over my own experience during this period, I have no doubt that some, perhaps most, of the cases of traumatic hemorrhage belonging to this category, which came under my own observation, might have been saved by transfusion, if seasonably performed. For this reason, I believe that the operation of transfusion will hereafter prove very useful in military as well as in civil practice, and that it justly claims the serious attention of all surgeons. The various modes of performing the operation have already been described in the first volume of this work, and I do not intend to repeat them here; but with a view to

emphasize the subject according to its importance, as well as to offer another and a somewhat better instrument for performing the operation, the accompanying woodcut (Fig. 414) is presented:—

Fig. 414.




Transfusion apparatus of B. E. Fryer, M.D., Surgeon U. S. Army.

This instrument is that of Aveling, modified by adding another bulb to the tube, and by having both tube and bulbs cast of the rubber into one piece. By the additional bulb, time can be saved in performing the operation, and the blood can be kept moving through the tube almost continuously. By having the tube and bulbs in a single piece, the metal portion which couples them in Aveling's apparatus is done away with, and thereby the risk of blood lodging and coagulating is diminished, while, if necessary, the whole apparatus may be more completely compressed. In Fryer's instrument, as in Aveling's, there are no valves; but in Fryer's the inner wall is perfectly smooth throughout, and the opening from tube to bulbs gradually slopes, thus entirely avoiding corners in which the blood might stagnate and coagulate.

The apparatus of Fryer consists of two parts, one of which is intended for immediate and the other for mediate transfusion. The addition of a glass vessel, marked A, which can be fitted to the tube at B, makes an instrument which can be used for mediate transfusion when desired.

The manner of using the instrument for *immediate transfusion* is as follows: The canula marked B is placed in the giver's vein; that marked C in the vein of the receiver. The tube and bulbs having been filled with warm water, or, better still, with a warm saline solution (consisting of sodium chloride, grs. 60, potassium chloride, grs. 6, sodium phosphate, grs. 3, sodium carbonate, grs. 20, and water, twenty ounces) are then to be adjusted to the canulæ, and the blood allowed to flow into the apparatus. The canulæ being steadied by an assistant, the tube is to be nipped tightly between the fingers, close to the giver's end, and then the bulb marked 1 is to be compressed, and the blood of course forced on toward the receiver. While this bulb is still held flattened, the nipping of the tube at the giver's end is to be relaxed, and the portion of tube between the bulbs is to be nipped instead; bulb No. 1 should then be relaxed, and bulb No. 2 should be compressed and held; next, the tube is to be tightly nipped at the receiver's end and held to prevent regurgitation, and the whole apparatus allowed to refill from the giver's arm. The same manipulation is to be repeated until blood enough is transfused. A considerable degree of force sometimes must be used in sending

blood or other liquids into the veins. A few drops of liquor ammoniæ may be injected into the bulbs, now and then, with a fine-pointed hypodermic syringe, in order to more effectually prevent coagulation.

The manner of using the apparatus for *mediate transfusion* is as follows: The glass vessel marked A in the cut is applied to the tube in place of the giver's canula, marked B, and has poured into it the blood to be transfused. The instrument is to be applied to the receiver's arm, and afterward to be worked in the manner directed above. If this blood be not defibrinated and strained, three or four drops of liquor ammoniæ must be added to each ounce, in order to prevent coagulation.[1] For other methods of performing this operation, and there are several, the reader has already been referred to the first volume of this encyclopædia.

When a patient is in danger of perishing from hemorrhage, resort should at once be had to transfusion, that is, to the introduction of blood from a sound person into the empty vessels of the patient. "I have seen," says Professor Agnew,[2] "patients who were dying from epistaxis rescued from the very verge of dissolution by the timely passage of a few ounces of blood into a vein of the arm. Not only is this operation indicated in excessive hemorrhage, but I have known several cases of obstinate anæmia greatly benefited by the same practice." The cases requiring transfusion may be briefly outlined as follows: (1) Those in which the hemorrhage occurs from large bloodvessels, and cannot be stanched until death is imminent. (2) Those examples of prolonged epistaxis, also, wherein death has become imminent. (3) Those instances of post-partum hemorrhage in which reaction cannot take place unless blood obtained extraneously is at once poured into the empty vessels. (4) Those cases of anæmic exhaustion, caused by great losses of blood, in which the ordinary measures prove insufficient to raise the patient; this class will be found to be unhappily numerous, especially among the wounded in time of war. (5) Inasmuch as depression from the loss of blood is one of the most important factors concerned in the genesis of blood-poisoning in surgical practice, it is often right to overcome it by transfusion.

The blood for transfusion must in all cases be taken from a human being, as that of animals does not answer the purpose. The donor should be a person in good health, entirely free from constitutional disease, and young also, if possible. In operating, the blood is usually thrown into the venous system of the receiver; but Hüter, of Greifswald, recommends that it be thrown into the arterial instead of the venous system, believing that it would thus pass into the heart in a more equable and less rapid manner. So, then, in cases where organic weakness of the receiver's heart, *e. g.*, fatty degeneration, is present, transfusing into the arteries, as advised by Hüter, would be preferable to transfusing into the veins.

The operation for immediate transfusion, described above, though simple, requires considerable skill and delicacy of manipulation; and those expecting to practise it, will do well to perform it a few times on animals, for then no difficulty will be experienced in operating on man. It proves most useful after profuse hemorrhage, where the vessels are comparatively empty and the vascular tension is but slight; in chronic cases, where the vessels have become filled again to about their natural capacity, the blood should be transfused in but small quantity at one sitting, that is about six ounces at a time, lest too great a strain be placed upon the heart. Throughout the whole procedure, great care must be taken against the entrance of air into the bloodvessels, for this accident might prove quickly fatal.

[1] Medical Record, April 15, 1874. [2] Principles and Practice of Surgery, vol. i. p. 176.

Immediately after the operation of transfusion, a rigor often appears; but, in a short time, it passes away. Occasionally, syncope is threatened; but this sense of faintness, too, quickly vanishes. In cases which have been judiciously selected, and in which the operation has been dexterously performed, an improvement in the patient's condition is soon seen. The pallid lips assume a rosy hue, the pulse regains its volume, and the patient himself acquires a consciousness of returning strength.

*Transfusion of Milk.*—The intra-venous injection of milk is now recognized as a perfectly feasible and legitimate procedure, not only in cases of exhaustion from hemorrhage, but also in disorders which greatly impoverish the blood, such, for instance, as cholera, pernicious anæmia, typhoid fever, etc.; it is very much easier of performance than transfusion of blood, and any one at all familiar with surgical operations may practise it without fear of great difficulty or of failure. The instrument required is a glass funnel with a rubber pipe attached to its stem, and ending in a very small bent canula for insertion into a vein. The milk should be withdrawn from a healthy cow within a few minutes of its use; it may be received in a warm pitcher, covered with carbolized gauze, through which it is strained. The median basilic or median cephalic vein is to be opened by a V-shaped incision; then the canula is to be plaçed in the wound, and the milk allowed to flow through it into the vessel, not more than eight ounces being introduced at one time. Transfusion of milk, like transfusion of blood, is commonly followed by a chill, with rapid and marked increment of body-heat; this, however, soon subsides, and great improvement in the patient's condition at once appears.

## Wounds of Arteries.

In discussing the injuries of bloodvessels I shall first take up the wounds of arteries, because they have the most importance. The traumatic lesions to which the arteries are exposed naturally range themselves under the following heads:—

1. Punctured Wounds.
2. Contused Wounds.
3. Lacerated Wounds and Ruptures.
4. Gunshot Wounds.
5. Incised Wounds.

This classification, while quite devoid of arbitrariness, is very convenient for descriptive purposes, and equally useful for the student and practising surgeon. The wounds of each group are characterized by peculiarities in respect to their phenomena and consequences, which are of practical importance, and which, therefore, deserve special mention.

## Punctured Wounds of Arteries.

These wounds, because of their comparative frequency, the difficult problems which their treatment sometimes presents, and their fatality, are of great interest and importance to surgeons. Maisonneuve has shown that an artery may be pierced by a delicate instrument, such as a fine needle, without producing hemorrhage, or any other unfavorable result. But if the vessel be pierced by a larger instrument, such as a tenaculum, disastrous consequences may follow. For example, Guthrie saw two cases in which the femoral artery was wounded by a tenaculum, and ulceration, followed by hemorrhage,

took place in both, requiring the application of ligatures.[1] Guthrie also thought that longitudinal fissures in the coats of arteries, one or two lines long, were not attended by bad consequences. But Deschamps's case shows that he was mistaken:—

In this case the brachial artery in the upper part of its course was opened by the point of a knife. The wounded man walked a little way; but, becoming weak from loss of blood, which was great, he fell to the ground insensible from syncope, and for a time the bleeding ceased. On the eighth day copious hemorrhage again occurred. On the ninth and tenth days small bleedings took place. On the morning of the eleventh day hemorrhage recurred to an alarming degree, the bed being soaked through with black and fetid blood. At noon the bleeding again returned with violence. The patient died, and, on opening the body, Deschamps found the brachial artery punctured in a longitudinal direction, at its external and posterior aspect, to the extent of two lines, opposite the inferior border of the tendon of the pectoralis major muscle, and above the origin of the superior profunda artery.[2]

In this case a traumatic aneurism resulted from the wound, for the relief of which several operative procedures were tried in vain, and the patient lost so much blood that, in the end, he lost his life thereby. Such were the consequences of a longitudinal puncture of the brachial artery, only two lines long. When the aperture is of greater size the risk is correspondingly increased, unless it is promptly averted by the surgeon's skill. When the puncture opens an artery obliquely or transversely to its course, it acquires a circular or rather a rounded shape, with consequent increase of size, from the action of muscular and elastic fibres in its walls, which are divided by the puncture. But the relation of a few examples will give more practical knowledge of this subject than many pages of general description:—

William Colles relates the following case: A laborer, aged fifty-six, was admitted to Steevens's Hospital, March 30, 1855. At dinner on the previous day he had swallowed a fish-bone, which, he stated, he felt cutting him very much at the time "in his chest," and this cutting pain was increased very much by the act of swallowing. Almost immediately he began to spit blood in large quantity, at first dark-colored, but soon bright-red. At twelve o'clock next day, when he entered the hospital, he complained of acute pain in his chest, and of great weakness. He had a blanched look and a hemorrhagic pulse. Immediately after admission he vomited a fish-bone, about one inch long, narrow and irregular in shape, with sharp points and cutting edges. He continued to vomit blood freely throughout the day, but not so freely as at first; the quantity gradually diminished until nine P. M., when he died. *Necroscopy.* The posterior mediastinum was filled with coagulated blood. The stomach contained a large clot, and the small intestines were also filled with coagula. There was found in the posterior wall of the œsophagus an oblong irregular opening, about half an inch in length, and extending from above downward; in the corresponding part of the aorta there was a longitudinal slit exactly opposite to that in the œsophagus, which differed only in being smaller and more irregular.[3]

In this case the swallowed bone stuck fast in the œsophagus; it cut quickly through the posterior wall of the gullet; and, being strongly impelled by the acts of swallowing, it pierced the front wall of the aorta, and caused traumatic hemorrhage, which speedily proved fatal. In this case, too, the punctured wound of the aorta was longitudinal, and scarcely more than three or four lines in extent; yet the hemorrhage was very profuse, and did not cease until it extinguished life.

[1] Diseases and Injuries of Arteries, p. 212.
[2] Observations on Aneurism, Sydenham Society's edition, pp. 406–409. London, 1844.
[3] Dublin Quarterly Journal of Medical Science, 1855, vol. xix. pp. 325, 326.

Another instance of punctured wound of, and primary hemorrhage from, the thoracic aorta, which belongs to the same category as the last, was also observed in Ireland only a few years ago. A woman named Nolan, aged 47, an inmate of Richmond Lunatic Asylum, at Dublin, died very suddenly after vomiting blood. The autopsy and the evidence adduced by the coroner showed that she came to her death in consequence of hemorrhage from a punctured wound in the aorta, caused by a sewing-needle which she had swallowed. This needle had perforated the posterior wall of the œsophagus, and pierced the anterior wall of the aorta; a part of it was found still embedded in the œsophagus, and it was covered with rust.[1]

This case as well as the last was not amenable to treatment, because the wounded artery was so placed in the body that it could not be exposed and tied by any surgical operation. Durham, however, relates a case in which the carotid artery bled from a punctured wound, extending to it from the pharynx, that was successfully treated by ligating the artery:—

A boy, aged 7, fell while holding the sharp end of a parasol in his mouth. The point came almost through the skin on the left side of his neck. Considerable hemorrhage occurred at once, and recurred at night. About the seventh or eighth day a slough came away by the mouth, followed by arterial hemorrhage to the amount of five ounces, which was stopped by pressure applied externally, when the boy was brought to St. George's Hospital. A swelling as large as the half of a hen's egg was found beneath the left ear, and the skin for some distance around was discolored, as from extravasated blood. The swelling fluctuated at the summit; it was opened, and pus with much blood-clot escaped, but no hemorrhage ensued. Two days later a gush of arterial blood followed a fit of coughing, and the common carotid artery was promptly cut down upon and tied by Mr. H. C. Johnson. Both wounds soon healed, and the boy made a good recovery.[2]

In the following instance of stab-wound of the neck, where the point of a knife punctured the internal carotid artery, the hemorrhage was checked by digital compression until the vessel could be tied on each side of the wound, and recovery followed:—

On July 31, 1869, a miller was wounded in the neck, at the angle of the lower jaw, by the large blade of a pocket-knife, which penetrated to the depth of several inches, and opened the internal carotid. Alarmed by the tremendous jets of arterial blood, Dr. J. M. Denning, in whose drug-store the stabbing occurred, immediately seized the man's neck, and compressed the carotids. Happening to be close at hand, Dr. A. T. Lee promptly cut down upon the artery by the usual incision, exposed it by careful dissection, found the bleeding point, and applied a ligature on the cardiac side of it.

The patient, who had fainted, now rallied, but severe arterial hemorrhage again occurred, the blood coming from above, through the circle of Willis, from the opposite carotid and the vertebrals. A ligature was then placed on the distal side of the wound in the artery, and the regurgitating hemorrhage at once ceased. The patient was now pulseless, and death was considered imminent; but under prompt and energetic stimulation with whiskey and ammonia, the circulation soon became good; respiration grew full and regular, and, fifteen minutes after the operation, speech returned. He was confined to bed five weeks, but made a good recovery ultimately, being still alive and actively employed over nine years afterward.[3]

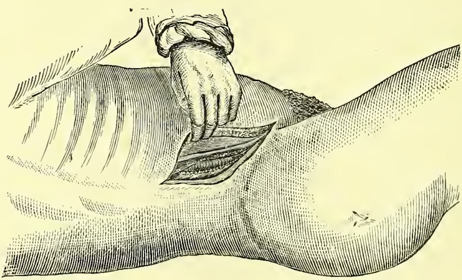
This case answers several good purposes. It illustrates the plan of treatment which, when practicable, is best calculated to save patients having punctured wounds of arteries, namely, the exposure of the bleeding point in the artery by enlarging the original wound, or by making fresh incisions, as

[1] Lancet, 1877, vol. ii. p. 789.
[2] Holmes's System of Surgery, vol. ii. p. 457.
[3] American Journal of the Medical Sciences, January, 1879, pp. 142, 143.

required, and then applying two ligatures to the artery, one on each side of the aperture. It shows why cases treated with proximal ligatures only are liable to prove, and not unfrequently have proved, fatal from a return of hemorrhage, the blood regurgitating through the distal portion of a wounded artery tied proximally on the establishment of a collateral circulation. And, finally, this case is historically important, as being the first where the internal carotid artery has been successfully secured with two ligatures for traumatic hemorrhage.

The next case occurred in the person of a soldier during the war of the rebellion. He was accidentally wounded by a bayonet-thrust in the right buttock, at Milwaukee, March 18, 1864, and was returned to duty July 12. He entered University Hospital, New Orleans, August 29, and was furloughed September 19. He entered the Marine Hospital, Chicago, September 30, and died October 11. At the time of injury there was bleeding to the amount of fifteen ounces. The urine was drawn by catheter for four days, and contained much blood. Great swelling in the iliac fossa and right buttock occurred immediately. The patient was sent to his regiment in Arkansas, after two months, but he could hardly walk with the aid of a cane. He suffered from what he described as "hammering pain" in the tumor, which was observed to pulsate. Topical applications afforded no relief. When admitted to Chicago Hospital, he was suffering great pain in the tumor and right lower extremity. He was anæmic and presented the constitutional symptoms attending great loss of blood. The tumor was red and glistening, and extended from the crest of the right ilium to the natal fold. The cicatrix of the bayonet-stab was nearly in its centre, and beside it was a puncture recently made for exploration by a surgeon on the transport steamer. The puncture was dilated to the size of a half-dollar and filled with coagula, through which, October 2, arterial blood escaped. There was numbness of the limb and dysuria. A bruit, but no audible pulsation, was found on auscultation. On October 2, an injection of perchloride of iron in solution was resorted to, with temporary arrest of hemorrhage, and injections were repeated on recurrence of the bleeding. It was decided to tie the common iliac.

Fig. 415.



Diagrammatic drawing of the incision in Isham's case of ligation of the right common iliac artery, for traumatic aneurism of the anterior trunk of the internal iliac artery, caused by a bayonet-wound. The bayonet-stab on the right buttock is also shown.

On October 7, the operation was performed by Dr. R. N. Isham, the patient being under chloroform. A curvilinear incision was made from in front of the extremity of the twelfth rib downward and forward to the crest of the ilium (Fig. 415), and along the crest, terminating near the anterior superior spinous process. The muscles and transversalis fascia were successively divided, and, the peritoneum being held out of the way by two fingers, the deep wound was enlarged to the extent of the external incision.

The peritoneum was lifted uninjured by the hand, together with the intestines, and the vessel was exposed to view, not a drop of blood obscuring the parts. The ureter was lifted with the peritoneum. A Mott's artery needle was passed under the vessel. The tightening of the ligatures not only arrested the circulation in the limb, but diminished the tumor, so that its tense surface became flaccid. The wound was closed; the limb was enveloped in cotton, and placed in an easy position; warm-water bottles were arranged near it; a half-grain of morphia was given, and oyster-broth. The patient had a good night, and the limb was of natural temperature. Pulse 113; a dose of four drops of tincture of veratrum viride was given at seven in the morning; at eight in the evening the pulse was 80. October 9, pulse 90; the discharge from the sac being offensive, the clots were turned out, and the sac was injected with a solution of the permanganate of potassium. October 10; discharge from sac very offensive. October 11; he died at 10 A. M.

The *autopsy* revealed no evidence of peritonitis. A well-organized clot extended from the seat of ligation to the aorta. The artery punctured was the anterior trunk of the internal iliac, within the sacro-ischiatic notch. The walls of the enormous sac were gangrenous. There was no appearance to account for the hæmaturia. The account of the case and the drawing have been taken from the Medical and Surgical History of the War of the Rebellion, Second Surgical Volume, p. 335.

In this soldier's case, the successive steps in his downward course were as follows: (1) the bayonet-stab of his buttock opened the anterior trunk of the internal iliac artery; (2) the formation of a traumatic aneurism ensued; (3) from continued neglect, this aneurism attained an immense size, the sac suppurated, the blood in it putrefied, the constitutional signs of septicæmia were rapidly developed, and death speedily resulted. Dr. Isham was satisfied, after the autopsy, that the method he adopted was preferable to the "old operation," an opinion to which, however, Dr. Otis, the surgical historian of the war, does not subscribe. The fact is, this case, from commencement to close, presented some of the most difficult problems of surgery. Theoretically, the wounded artery should have been tied on each side of the aperture in its walls, as soon after the mishap as possible. But this operation could not have been performed through any incision made in the gluteal region. How, then, was the wounded part of the artery to be reached and exposed, and tied? It might have been done with certainty by opening the abdominal cavity, as in ovariotomy, and approaching the vessel through the pelvis; but the surgeon would be justified in pausing long and pondering much before undertaking this operative procedure, as he would, also, at an early stage of the case, with regard to ligation of the common iliac artery, inasmuch as that operation would offer but little hope of success in a part where communication by anastomosis among the terminal branches is so free.

But the policy of delay which was pursued in this man's case from March to October wrought no good. Moreover, the history shows very clearly that as time went by the chances of his recovery steadily diminished, and that without radical treatment of some sort his recovery was not at any time possible. These points are eminently practical, and cannot be too strongly impressed upon the attention of surgeons. The plan of treatment which appears to have been adopted at the outset of this case, and followed more than six months, was fatally defective, because it did not recognize the absolute necessity of closing the orifice in the wounded artery by the application of ligatures, or, in default thereof, by securing the formation of an organizable blood-clot in the canal of the wounded artery.

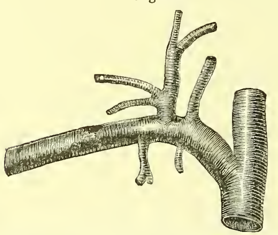
What, then, should the surgeon of to-day do when called on to treat a stab-wound of the buttock penetrating the pelvis, and opening the internal iliac artery, or one of its main branches? After staying the external bleeding, his thoughts should at once be directed to stopping the internal bleeding also. If necessary to a more exact diagnosis, he should explore the pelvic

cavity with his hand introduced into the rectum, as practised by Sands in analogous cases.[1] But, before doing even this, he should try the effect of compressing the common iliac artery, on the same side as the wound, with his fingers, firmly, against the last lumbar vertebra or the brim of the pelvis. If in this way the bleeding were controlled, as in most cases it probably would be, as indicated by diminished tension and swelling, with disappearance of pulsation in the tumor, he should direct the compression to be continued digitally, or by a suitable tourniquet, or by Esmarch's elastic bandage, applied in some of the ways already described, until the blood had coagulated in the tumor itself and in the canal of the wounded artery. He should most earnestly strive to obliterate the wounded artery by compressing the common iliac, or, if that were impracticable, by compressing the adjoining aorta; for he could not ligate the bleeding artery in the external wound; it would not be justifiable to reach it by opening the belly as in ovariotomy; and the operation of tying the common iliac, on the plan of Hunter, would be far too serious and uncertain of result to be resorted to at the outset.

Again, the arteries are sometimes pierced from within the body by sharp fragments of bones that have been broken by the impact of gunshot projectiles, as happened in the following instance:—

A soldier[2] was admitted to hospital September 20, 1864, with a gunshot wound of the right side of his neck, received on the previous day. He was very weak from hemorrhage from the wound and from hæmoptysis. Notwithstanding plugging of the wound, etc., the hemorrhage and the hæmoptysis continued, and on October 5, death resulted. *Necroscopy.* A conoidal musket-ball had entered the right inferior triangle of the neck, fracturing obliquely the first rib at its middle, and depressing the sternal

Fig. 416.



Perforation of the right subclavian artery by a sharp fragment of the adjoining first rib, fractured by gunshot. (Spec. 3377, sect. 1, A. M. M.)

Fig. 417.

First rib fractured obliquely by gunshot; a fragment perforated the right subclavian artery. (Spec. 3376, sect. 1, A. M. M.)

portion thereof into the apex of the right lung; the other fragment stuck upward with a sharp-pointed end, which perforated the subclavian artery in the second part of its course. The missile emerged from the back above the spine of the scapula. The mediastinum and the right pleural cavity were filled with extravasated blood. The right intercostal spaces bulged outward. The heart was pushed toward the left. The right lung was collapsed. There were marks of periostitis on both portions of the rib. The appearance of the artery, well represented in Fig. 416, indicated that the laceration of its walls had occurred either at the time of impact of the missile, or from some sudden movement of the shoulder, rather than from gradual attrition. The broken rib is drawn half size in the accompanying illustration (Fig. 417).

[1] American Journal of the Medical Sciences, April, 1881, pp. 366–373.
[2] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 521.

But minute missiles discharged by fire-arms, such as bird or squirrel shot, may themselves inflict on large arteries minute lesions which closely resemble, if they are not identical with, punctured wounds. The following example occurred in the practice of Prof. S. D. Gross :—

A strumous lad, aged 14, was wounded in the neck by the accidental discharge of a fowling-piece, loaded with large-sized squirrel-shot, which entered the neck at four or five different points. The casualty was attended with but little hemorrhage, and the symptoms of shock soon passed away. The wounds healed without any application, and everything went well until thirteen days after the accident, when the patient was seized, suddenly and without warning, by a protracted epileptic convulsion, affecting chiefly the left side, and died the following day, without return of consciousness. *Autopsy.* One shot had perforated the subclavian artery, and had lodged in the first rib. The calibre of the vessel was unimpaired, and the apertures were closed by small clots extending around the exterior of the vessel, upon the removal of which the margins of the wounds appeared as if they had just been inflicted. The artery presented no marks of inflammation.

Another shot had perforated the anterior wall of the right internal jugular vein, and had lodged on the inner surface of the opposite wall, where it had become completely encysted. The vein bore no evidence of inflammation. The opening in the anterior wall was perfectly closed, and there was no external nor internal clot. The lumen of the vein, however, was somewhat diminished by the projecting cyst.[1]

It is of interest to observe that, in this case, the shot-hole in the great jugular vein was found, after the lapse of fourteen days, perfectly closed or healed without the aid of blood-clot, and without inflammatory engorgement. This wound had therefore united by the first intention, as usually happens after venesection.

The minute apertures in the subclavian artery were closed by small clots extending around the exterior of the vessel, without invading its canal. J. L. Petit long since pointed out that in such cases clots form which fill the apertures in the wall of the artery, and exactly close them, without encroaching upon the canal of the artery. He says these clots are shaped like nails, the points of which equal in length the thickness of the arterial wall, while their extremities, which correspond to the moving column of blood, are worn off by the friction they undergo. Their heads, which correspond to the exterior part of the artery, are very broad; they contract adhesions with the external surface of the artery and the adjacent cellular tissue. These adhesions become stronger, and when they are well cemented the artery is healed, and the clots cannot be displaced by the impulse of the blood which continues to pass through the artery, as before the injury. Exactly such as Petit describes, were the small clots found in the case just related, closing the minute shot-holes or punctures in the subclavian artery. Had the boy lived, it is highly probable that these clots would soon have become fully organized, and thus have effectually sealed the minute punctures with newly formed tissue. Hodgson, also, remarks that when an artery is punctured the hemorrhage is sometimes arrested by the formation of a thin layer of coagulum over the orifice in the vessel, and that the edges of the wounded artery are subsequently united by an effusion of lymph, in the same manner as wounds in soft parts in general are healed by adhesive inflammation. This mode of reparation, by which the continuity of the tube is preserved, takes place more readily when an artery is wounded longitudinally, as well as to but small extent, than when the wound is transverse or oblique; for in the latter cases the retraction of the artery causes the orifice in its wall to assume a circular form, in consequence of which the effusion of lymph is greater than

[1] American Journal of the Medical Sciences, January, 1867, pp. 41, 42.

when the edges of the wound are more closely approximated, or placed in contact. It is, then, by the organization of blood-clot and the effusion of coagulable lymph that minute lateral wounds of arteries may become closed without obstructing their canals: and, doubtless, those rare instances on record in which the aorta and other large arteries have been punctured without any permanently bad consequences, were of this character, and were healed in this manner.

It must be admitted, however, that such instances of perfect cure of punctured wounds of arteries are quite exceptional and rarely to be expected. And when we consider that most persons who have had an artery pricked, and who have been treated by compression, have also had a false aneurism, we cannot help thinking that their cure has been only apparent. In this way circumscribed traumatic aneurisms appear after puncturing the brachial artery in venesection, when compression is used; the patient is thought to be cured, and the surgeon feels safe; but in three or four months, sometimes later, the clot by which nature has arrested the hemorrhage, becomes detached, or the newly formed tissue by which the aperture was closed, yields to the pressure of the blood, and an aneurismal swelling forms.

Causes.—Punctured wounds of arteries may be inflicted with the sharp points of scissors, as happened in a case reported by Deschamps, where the femoral artery was pierced in this way; with penknife-blades, as in several cases which have been reported; with lancets, in bleeding at the elbow, as has often happened in both ancient and modern times; with pocket-knives, many instances of which accident have been recorded; and, finally, with daggers, swords, bayonets, or any other narrow-bladed weapons. Arteries may also be fatally pierced by sharp fragments of bone, and by sewing-needles, when swallowed. Arteries may be punctured by sharp fragments of necrosed bone, as happened some years ago in New York, in a case where the popliteal artery was pierced by the point of a femoral sequestrum, and with a fatal result. Again, punctured wounds of arteries may be caused by fragments of bones that have been broken by the impact of gunshot projectiles; they may also occur in comminuted fractures, simple as well as compound, that have been produced by other means. Puncturing of arteries from fragments of broken bone is believed to occur in the leg more frequently than in any other region, and this view is supported by Dupuytren's published cases. Arteries, too, may be punctured by sharpened sticks, or by splinters of wood.

Symptoms.—Punctured wounds present nearly the same phenomena as those made by cutting instruments; there is always bleeding, to a greater or less degree; but the pain is frequently much more severe, since the instrument often tears the parts. Hemorrhage takes place when the puncturing instrument has met in its course an artery of some size, and pierced or divided it; in either case, blood escapes externally, when the wounded artery is superficial, and the wound itself has been made perpendicularly to the skin; but when the puncturing instrument has passed very obliquely into the part before reaching the artery, the blood infiltrates into the connective tissue and produces a diffuse traumatic aneurism, unless the escape of blood from the artery be quickly stopped, by compressing the artery itself at the wound, or by compressing the main trunk above, that is, on the cardiac side of the wound, through the soft parts by which it is covered. In the latter case, there may quickly be formed at the aperture in the artery a clot of blood, which prevents further hemorrhage; but if the compression be not properly made, or if it be not sufficiently strong, or if it be not continued long enough to

obliterate the injured vessel, the clot soon becomes detached, and the escaping blood forms a circumscribed traumatic aneurism. In all cases of diffuse traumatic aneurism, and in many cases of circumscribed traumatic aneurism, there is actually traumatic hemorrhage going on unchecked, but the bleeding is internal and concealed from view instead of being external and exposed to sight. When the aorta is pierced by a sewing-needle or by a sharp fragment of bone that has been swallowed, the discharge of arterial blood from the mouth by vomiting is always a prominent symptom.

Consequences.—Punctured wounds involving arteries may be attended with the complications or consecutive phenomena which are common to punctured wounds in general, such as phlogosis, with acute pain and severe irritation, etc. Moreover, they are very fatal. Of the illustrative examples given above, six ended in death and only four in recovery. Of eleven stab-wounds involving the vertebral artery, collected by Kocher, only two terminated favorably. Punctured wounds of the femoral and axillary arteries are of not unfrequent occurrence, and often prove fatal. The first bleeding may end in death; or, if it be inadequately treated, it may recur again and again, until it wears out and finally kills the patient by exhaustion. Again, if the blood continue to escape from an artery into the connective tissue while the external wound is closed, in the primary period, there occurs a diffuse traumatic aneurism, which is only another name for primary arterial hemorrhage taking place internally. If such an inward bleeding occur in the fore part of the neck, the resultant swelling may so compress the larynx and trachea as to cause death by suffocation. If it occur in the loose connective tissue of the armpit or thigh, the extravasated blood may burrow very widely as well as cause great tumefaction, from which there may result a suppurative inflammation of the infiltrated connective tissue, with putrefactive changes in the effused blood, followed by septicæmia and death.

Diffuse traumatic aneurisms are very liable to follow punctured wounds of arteries, and must be reckoned among the most important of their consequences. They will be fully discussed in the section on Traumatic Aneurism.

Arterio-venous aneurisms sometimes follow punctured wounds which simultaneously involve arteries and their contiguous veins. They occur most frequently at the bend of the elbow from mistakes in bloodletting; but they have also been met with in the neck, thigh, and other regions. They will be fully discussed in the section on Aneurismal Varix and Varicose Aneurism.

Punctured wounds of arteries, when very minute, and not attended with much primary bleeding, are occasionally followed by severe secondary hemorrhage, from ulceration of the artery at the place of injury, as happened in three instances (two related by Guthrie and one by Durham) that are mentioned above. There is also a specimen in our Army Medical Museum which illustrates a similar occurrence. It consists of a popliteal artery, from which secondary hemorrhage took place eleven days after it was punctured by a spiculum of bone. The femur was obliquely fractured by a pistol ball, in its lower third, with slight comminution. The artery did not bleed until its coats sloughed at the place of puncture. The hemorrhage was then arrested by tying the femoral, but traumatic gangrene of the limb supervened, and death occurred three days after the operation.[1]

Treatment.—The course which is most likely to avert the disastrous consequences just enumerated, consists of promptly exposing the wounded artery at the place of injury by suitable incisions, and applying two ligatures to it,

[1] See Catalogue of the Army Medical Museum, Specimens 4084, 4085.

one on each side of the bleeding orifice, as recommended by the ancient surgeons. But before this operation can be performed it is often advisable to restrain the bleeding by compressing the wounded orifice and main trunk of the injured artery, with the fingers, or with a suitable tourniquet, or with Esmarch's elastic bandage, according to methods which have already been described, whether the blood be escaping through an external wound or infiltrating the connective tissue around the artery. With regard to the employment of compression for punctured wounds of arteries, the rule is to consider it a temporary expedient, since it often procures only transient relief, and leaves the patient exposed to false consecutive aneurism. There are, however, some important exceptions to this rule, which will presently be mentioned. A ligature should be applied on the distal as well as on the proximal side of the aperture, because, unless this be done, the hemorrhage is liable to occur again, as soon as the parts beyond the wound become well supplied with blood through the anastomosing branches or collateral channels. The blood then regurgitates in the distal part of the artery, and is very liable to force its way through the distal orifice, unless the artery is here also closed with a ligature. The artery should moreover be divided midway between the two ligatures, so that both ends can freely retract.

Punctured Wounds of Special Arteries.—*Vertebral Arteries.*—We pass now to the consideration of some points in the treatment of punctured wounds of arteries which are surrounded with great difficulties. No single point, perhaps, is more puzzling than to devise a satisfactory plan of treating wounds of the *vertebral artery.* Almost all the recorded cases, and their number is not small, have proved fatal. This vessel lies so deep, and the diagnosis of its lesions is so difficult, that in eleven instances of traumatic aneurism involving it, the carotid has been tied through mistake. The explanation is that when the carotid is compressed against the so-called carotid tubercle of Chassaignac, on the transverse process of the sixth cervical vertebra, the vertebral artery also is compressed, at its point of entry into the foramen of the transverse process. The deception is not removed by compressing the carotid at a higher point, for the vertebral may pass up the front of the transverse processes. In recent wounds, the best way to ascertain the vessel from which the blood issues, is to insert into the wound a finger, with which the jets of arterial blood may generally be felt, and the relation of the wounded vessel and of the hemorrhage to the transverse processes of the vertebræ determined. Ligature of the vertebral artery for practical purposes is impossible except in a portion about six centimetres, or two and three-eighths inches, long, between its origin and its entrance into the transverse foramen of the sixth cervical vertebra. In this part of its course it has been successfully tied by Smyth, of New Orleans, for regurgitating hemorrhage; in this part, also, it has been tied, together with the inferior thyroid artery, by Maisonneuve, in order to arrest hemorrhage attending a shot wound of the neck—with success, as far as stopping the hemorrhage and extracting the ball were concerned, though death occurred from infiltration of pus into the spinal canal, and consequent inflammation. But these successes, complete and partial, afford some encouragement. Having determined by exploring the wound with a finger, or by any other means, that the vertebral artery is punctured in this part of its course, the bleeding point should at once be laid bare, and a ligature should be put round the artery on each side of the aperture. But when the exploration shows that the artery is wounded above the point where it enters the foramen of the transverse process of the sixth cervical vertebra, how can we suppress the bleeding and save the patient? We cannot tie the artery in the wound; and to tie it in the first part of its course,

on Anel's plan, would fail, because the two vertebrals unite to form the basilar artery at the base of the brain, and therefore regurgitating hemorrhage would occur in the wound whenever the direct hemorrhage might be stopped in this way. Distal ligature of this artery, between the occipital bone and the atlas, as suggested by Dietrich, would be both difficult in performance and uncertain in result. There remains, then, only the operation of plugging the wounded artery, a measure which has been successfully employed in one case by Dr. Kocher, of Bern.

On dilating the wound in the neck by suitable incisions both longitudinal and transverse, and removing the coagula, the blood was seen to come from a point between the transverse processes of two vertebræ, apparently the fifth and sixth. Arterial blood escaped from both the central and the peripheral portions of the artery; and the bleeding was arrested by pressure against the transverse processes, either from above or from below. As a ligature could not be applied, a plug of charpie of the size of a pea, soaked in solution of perchloride of iron, was introduced between the transverse processes, and left there, as soon as it had been ascertained that the bleeding was suppressed. The external wound having been closed by sutures, was covered with charpie dipped in carbolized glycerine, Lister's carbolic-acid paste was applied, and the dressing was retained in place by a bandage. The head was kept fixed by a stiff collar. The plug in the deep part of the wound was removed on the fourth day after the operation, partly by means of a stream of water, partly by forceps; no bleeding followed. Excepting a slight attack of erysipelas, the patient progressed steadily toward recovery, and was discharged cured a little more than five weeks after the operation.[1]

But in order to secure the success of this operation of plugging the vertebral artery, it is essential that the bleeding point in the vessel shall be exposed to view, that the plug shall be placed exactly in the open canal of the vessel, which it must completely fill, and that the patient's head shall be held fixed, and the neck immovable, by a stiff collar. False consecutive aneurisms of the vertebral artery are not unfrequently met with; they will be discussed in the section devoted to the subject of Traumatic Aneurism.

*Carotid Artery.*—Punctured wounds involving the *common carotid* artery, or its branches, are often met with, owing to the exposed situation of the parts supplied with blood by the carotid system of vessels; and, from the comparative ease of performing the operation, ligation of the common trunk for suppressing hemorrhage from these wounds, has probably been resorted to much more frequently than has been desirable. In instances too numerous to mention, the common carotid artery has been tied for lesions of its branches, without success, when the result would have been quite different had the wounded artery itself been properly secured. It is therefore imperative, when branches of the *external carotid*, for instance, are opened by wounds, that they should be tied at their wounded part with ligatures placed on each side; and, in cases where the performance of this operation, as well as ligation of the trunk of the wounded vessel itself, is impracticable, it is equally imperative that the external carotid should be tied, and not the parent trunk of all. In two instances, Stephen Smith ligatured the external and internal carotid arteries, just above the bifurcation of the common carotid, for hemorrhage from various points of the face and neck, and into the mouth and fauces; in one case it was for cancer, and in the other for gunshot injury. He thought thus to avoid renewal of the bleeding better than by ligature of the common trunk. In neither case was there any return of the bleeding, the ligatures separated well, and the patients recovered.[2] Again, in cases of hemorrhage from branches of the external carotid, such as the lingual, inter-

[1] Sydenham Society's Biennial Retrospect, 1871–2, p. 203.
[2] American Journal of the Medical Sciences, April, 1874.

nal maxillary, etc., when ligation of the corresponding external carotid fails to stop the bleeding, the external carotid on the opposite side should also be tied, and not the common trunk; for ligature on both sides of the external carotid artery has hitherto, I believe, been uniformly successful in subduing such hemorrhages.

In wounds involving the trunk of the *common carotid*, or that of the *internal carotid*, or that of the *external carotid*, the hemorrhage should be stayed, if possible, by digital compression applied in the wound or to the trunk of the common carotid, in the ways already pointed out, until a surgeon can be brought, and ligatures placed on each side of the orifice in the wounded vessel. Moreover, the application of distal ligatures is especially necessary in wounds of the carotids, as well as in those of the vertebrals, because of the remarkably free intercommunication which exists at their terminal extremities, through the circle of Willis. In connection with the treatment of hemorrhage from a lesion of the *internal carotid artery*, read the successful case of the miller quoted on page 112.

*Occipital, Temporal, and Facial Arteries.*—When the *occipital artery*, or the *temporal*, or the *facial*, or any other accessible branch of the external carotid is opened by a punctured wound, we repeat, the bleeding must be restrained by firmly compressing the primitive carotid artery against the transverse processes of the vertebræ (Fig. 342, p. 68); the injured part of the artery must be laid bare by incisions, and the bleeding orifice must be distinctly brought into view; a ligature must be applied on each side of the orifice, and the artery itself must be completely divided midway between the two ligatures, to allow the ends to retract. But if the injured part of the artery cannot be thus exposed and ligated, a ligature should be applied to the injured artery on the cardiac side of the wound, as near to it as practicable. If this cannot be done, the external carotid artery should be tied, but not the common carotid. Should the hemorrhage still continue, the external carotid artery of the opposite side should also be tied; this procedure is said never to fail, as already stated above.

*Axillary Artery.*—Punctured wounds which open the *axillary* artery are also very liable to be quickly followed by death from hemorrhage; and the internal or subtegumentary bleeding may be, and often has been, but little less deadly than the outward bleeding. Here, too, for saving the patient, our chief reliance must be placed on adequate compression, promptly applied, either with fingers in the wound, directly on the aperture in the vessel, or with both thumbs upon the subclavian artery as it passes over the first rib, or with a large door-key, or the thumb-piece of a Petit's tourniquet, suitably covered by bandaging, in order to restrain the escape of blood from the artery, internally or hiddenly as well as externally or openly, until surgical aid can be obtained, and until the vessel can be tied where it is wounded. But, in most cases, to be successful, the pressure must be applied intelligently, energetically, and steadily, as well as promptly, and with a strong desire to prevent the formation of a sanguineous tumor in the loose connective tissue of this region, as well as to restrain the outward flow of blood. The formation of a large, diffuse, traumatic aneurism in this region, is to be deprecated almost as much as an unobstructed external hemorrhage.

*Brachial Artery.*—Punctured wounds which involve the *brachial* artery should always be treated on the orthodox plan of ligating it above and below the wound as soon as possible, the hemorrhage meanwhile being restrained by compression, which, in this region, can readily be applied. Old soldiers have not unfrequently done it well for comrades with tourniquets extemporized from handkerchiefs. On laying the bleeding point in the artery bare for the purpose of securing it with ligatures, a stream of blood is

sometimes distinctly seen by the surgeon, issuing from the distal orifice after the proximal ligature has been tied (regurgitating hemorrhage), which already shows the necessity of applying distal as well as proximal ligatures in these wounds. A soldier, aged 23, was accidentally wounded August 18, 1864, by a bayonet-thrust at the bend of the elbow, cutting the brachial artery. The vessel was tied on each side of the wound, and the man recovered. All the patients treated in this way did well. Not so, however, with some who were treated on other plans; for Dr. Otis, the surgical historiographer of the war, says: "There were one or two cases in which the reports convey intimations that stabs in the arm, implicating the brachial artery, proved fatal from malpractice—compression and styptics having been resorted to instead of ligation."[1]

The following example, in which the *brachial artery* was punctured in the bend of the elbow with a penknife, will usefully illustrate what the treatment must be in order to prove successful: A good deal of blood was lost at the time, pouring out in a stream, not in jets, for the wound was an indirect one, the knife having entered obliquely. The patient was taken home, and the wound was strapped and bandaged; this arrested the hemorrhage temporarily. But the bleeding recurred several times, until finally the original wound was enlarged by incisions, the coagula were turned out, a traumatic aneurism that was forming was laid open, and ligatures were passed around the artery above and below the wound. Recovery followed without any difficulty whatever.[2]

*Arteries of the Forearm.*—Punctured wounds of the *radial*, *ulnar*, and *interosseous arteries* or their branches, and the hemorrhage resulting therefrom, in recent cases where the parts are sound, will give the surgeon but little trouble, provided he treats them on the orthodox plan of bringing distinctly the bleeding orifice into view, applying a ligature on each side of it, and dividing the artery midway between the two ligatures, so that the ends may retract. But if the surgeon should rely on styptics and compression in such cases, he will have much trouble which could readily have been avoided by ligating the injured vessels at the outset, above and below their wounds.[3]

*Palmar Arch.*—Punctured wounds of the *palmar arch* always excite apprehension, and give much trouble to the surgeon. Considerable differences exist among the plans of treatment recommended by eminent surgeons for this form of injury. Bryant points out that "extreme flexion of the forearm upon the arm, with forced supination of the hand, with or without a pad at the bend of the arm," arrests completely the circulation through the brachial artery; and that "under all circumstances, whether for injury or disease of the arteries of the hand and forearm, in which surgical interference is requisite, it would be well to remember this treatment, it being most effective."[4] Many favor compression. The readiness with which it can be applied to the hand predisposes strongly to its use. This mode of treatment, however, is not a good one—is not to be commended, for it very often fails. Every surgeon has seen examples of such a failure. The medical journals contain reports of many cases in which compression proved to be insufficient to control the hemorrhage from punctured or incised wounds of the palm, and ligation of the radial and ulnar arteries, and of the brachial artery, as well as other operative procedures, were resorted to in order to remedy this insufficiency. Compression is but ill adapted to restrain hemorrhage from wounds involving the palmar arches, because of the wonderful flexibility of the hand itself, and

[1] Medical and Surgical History of the War of the Rebellion, Second Surgical Volume, p. 437.
[2] British Medical Journal, May 29, 1869, p. 492; see also the section on Incised Wounds of the Brachial Artery.
[3] See also under Incised Wounds.
[4] Manual for the Practice of Surgery, p. 350, second Am. ed.

the great freedom of communication which exists among the terminal branches of the arteries in the hand through the medium of large inosculations. Some of the conditions most essential to success with compression, are quite wanting in the hand and wrist. Moreover, it is the treatment by compression that has furnished those instances, by no means rare, in which the patient has become pale and weak, or exhausted, from frequently recurring hemorrhages from wounds of the palm, and in which the wounded part itself has become infiltrated and boggy, and too much swollen and discolored to permit the injured artery to be laid bare and securely tied in the wound, without a great deal of difficulty.

Wounds of the palmar arch or of its branches form no exception to the general law that wounded arteries must be secured by ligatures applied on each side of the lesion, and that in case the artery is not severed by the accident, it must be divided by the surgeon midway between the two ligatures, so that retraction of the ends may take place. In all cases of surgical hemorrhage from wounds of the palm, the wound itself must be explored at the outset, and the source of the bleeding at once ascertained. While doing this it must be considered that between the palmar arches and the radial, ulnar, and interosseous arteries, a free intercommunication of branches exists, which branches are singularly uniform in their size; and that, in consequence, the distal part of the injured vessel may be almost as much inclined to bleed as the proximal. When the opening in the skin or the aponeurosis is not large enough to allow free access to the bleeding orifice, it must be enlarged to the required extent. In making incisions for this purpose, all thrusts with the bistoury must be avoided. The surgeon must understand and call to mind the arrangement and distribution of the vessels, and with such a knowledge he may proceed with entire confidence to lay bare the deep part of the hand. The skin must first be divided, and next the superficial fascia, when the palmar aponeurosis will be brought into view, and can readily be recognized by its white, tendinous appearance. The important vessels all lie beneath this structure. To open this dense membrane with safety, a slight perforation should be made through its substance, and a grooved director introduced, by means of which this aponeurosis can be raised up from the bloodvessels and nerves underneath, and its division successfully accomplished, thus giving an exposure of the parts sufficiently large for bringing into view and for successfully tying any vessel that may be wounded therein, according to the precept stated above. Dr. Ogston, in a difficult case, where the deep palmar arch was punctured by a knife-blade, succeeded in exposing the aperture in the artery to view by detaching the origin of the abductor indicis from the metacarpal bone of the index finger—that is, from the outer side of that bone. Then the artery was readily tied above and below the lesion. The patient made a good recovery.[1] Esmarch's apparatus for elastic compression was applied to the limb in this case, so that the operation was completed without loss of blood; and, in similar cases, it is generally advisable to prevent hemorrhage by the same method.

After ligating the palmar arch or its branches, and especially when the tissues are infiltrated and boggy or unsound, the force of the circulation in the hand should be lessened by keeping it in an elevated position, and by applying pressure to the radial and ulnar arteries by means of oblong compresses (Fig. 347, p. 71) placed on the forearm, and secured by a roller, beginning at the hand, and extending up to the elbow.

How should the neglected cases of wounds involving the palmar arch—those in which anæmic exhaustion from frequently recurring hemorrhages

[1] British Medical Journal, January 24, 1876, p. 782.

has ensued, and the tissues in the wounded palm are infiltrated and boggy, swollen, and discolored—how should such cases be treated? For them also the plan of treatment should be the same. The wound must be explored; the injured artery must be brought into view, and secured with ligatures in the wound. My own views coincide with those of Mr. C. D. Arnott, when he says: "The principle I wish to inculcate is that, under no circumstances, in hemorrhage from the palm, is deligation of the arterial trunks on the cardiac aspect to be deemed necessary or attempted. I am aware that this will at present hardly find general favor. I am, however, certain of my fact, and therefore state it boldly."[1]

*Femoral Artery and Branches.*—Punctured wounds of the thigh which open the common trunk of the *femoral artery*, or the *superficial femoral*, or the *profunda femoris*, however slight the puncturing of the artery may be, are very dangerous, and sometimes they are also very difficult to treat. A great many patients have been destroyed by these wounds. The main point in the treatment, however, is to restrain the primary hemorrhage, internally or at the orifice of the wound in the artery, as well as externally or at the orifice of the wound in the skin, without any delay, and without any temporizing with useless expedients. The formation of a diffuse aneurism in the femoral region is to be deprecated about as much as in the axillary region. In treating punctured wounds of the femoral artery, the bleeding should be restrained, both internally and externally, by exploring the wound with a finger, and placing the end of it upon the aperture in the artery; or by applying the elastic compression of Esmarch to the limb both above and below the wound; or by applying tourniquets or handkerchiefs tightly round the thigh above and below the wound, and thus controlling the circulation until the bleeding aperture in the artery can be laid bare by enlarging the wound, and until a ligature of carbolized catgut can be placed on each side of the aperture, and the artery itself be completely divided midway between the two ligatures to allow the ends to retract. Compression, although it is indispensable in such cases, must be looked on as a temporary expedient; as merely a very efficient means of preventing such a loss of blood as would prove fatal, or of keeping the patient in a salvable condition until the wounded artery can be properly secured by ligatures. The following case shows in a most excellent manner how punctured wounds of the femoral artery can be successfully managed:—

The subject was a young man, who, while mending a pen, accidentally let the knife penetrate his thigh at the middle. Free hemorrhage followed, which, however, was temporarily controlled by a handkerchief tied tightly round the limb. Mr. Maunder, on arriving, proceeded to search for the wounded vessel. He passed a finger readily into the wound to the depth of two inches, and felt the hole in a vessel which proved to be the superficial femoral artery. The finger being retained on this hole, the wound was enlarged upward and downward until the aperture in the artery was distinctly seen, and then a ligature was applied both above and below it. Venous-looking blood was observed to flow from the distal part of the artery. No discomfort attended the ligatures, which came away on the twelfth and thirteenth days respectively. The man made an excellent recovery.[2]

Here is another case in point: Mr. Messiter showed a patient who, in consequence of a punctured wound of the femoral artery, had acquired a diffuse traumatic aneurism. Mr. Houghton, three weeks after the accident, cut down upon the artery, and tied it above and below the wound. The patient made a good recovery.[3]

[1] Lancet, vol. ii., 1855, p. 141. See also observations on Incised Wounds of the Palmar Arches.

[2] British Medical Journal, November 23, 1867, p. 474.

[3] Ibid., March 2, 1878, p. 302. See also section on Incised Wounds of the Femoral Artery.

In punctured and in incised wounds of the thigh where apparently the femoral artery is involved, it may be found on enlarging the wound that a large branch is pierced or cut, and not the femoral artery itself. In the following example, the *internal circumflex* branch of the profunda femoris was the seat of the lesion:—

Private John Davis, Co. C, 41st Infantry, aged 22, received on March 13, 1869, at Fort Clark, Texas, a punctured wound of the thigh. He was admitted to the post hospital, where the wound was enlarged, and the internal circumflex artery was ligated, under ether. Five days later, the ligature was removed, and the wound was filling with healthy granulations. On May 12, he was returned to duty.[1]

In this case the injured artery was tied without delay in the wound; the patient rapidly and completely recovered. But had a policy of delay been adopted, or had styptics and compression been employed to control the bleeding, a diffuse aneurism would have ensued among the deep muscles on the inner side of the thigh, and the consequences would have been extremely disastrous.

*Popliteal Artery.*—Punctured wounds of the *popliteal artery* have been caused by the sharp ends of sequestra, by the sharp points of fracture splinters, by sharp slivers of wood, and by the points of bayonets, dirks, and other like weapons. These wounds have been treated by tying the artery above and below the aperture, according to the method of the ancient surgeons, by tying the femoral artery on the plan of Hunter, and by cutting off the leg. No one of these procedures will suit all cases. When gangrene is present or imminent, and, by the way, gangrene frequently ensues after this lesion, amputation performed without any delay is our sole resource. For hemorrhage, whether primary or secondary, the artery must be tied above and below in the wound. In some cases of traumatic aneurism resulting from a punctured wound of the popliteal artery, where there is a tolerably well-defined sac, it may be advisable to ligate the femoral artery on Hunter's plan, as being less likely to be followed by gangrene than the "old operation." Each case, however, must be critically examined, and that procedure must be applied to it which appears most likely to save the patient's life.[2]

*Tibial Arteries.*—Punctured wounds of the *posterior tibial artery* are occasionally met with; an example of this lesion was reported during the Crimean war, occurring in the person of a color sergeant belonging to the 18th regiment, who had been accidentally struck in the leg by the bayonet of one of the men, and whose posterior tibial artery was wounded. The case, however, presented no peculiarities. The wound was enlarged, the bleeding aperture in the artery was brought distinctly into view, and a ligature was applied on each side of it. The man recovered.[3] In such cases the artery should also be divided midway between the two ligatures. In many cases where the posterior tibial or the anterior tibial artery is punctured, the performance of the old operation for ligating the injured artery in the wound, can be facilitated by applying the elastic compression of Esmarch to the leg above and below the wound in such a way as to effectually control the circulation.[4]

*Plantar Arch.*—Hemorrhage from punctured wounds of the plantar arch must be treated on the same plan as hemorrhage from punctured wounds of the palmar arch, which have just been fully discussed.

[1] Circular No. 3, War Department, S. G. O., August 17th, 1871, p. 242.
[2] See also Incised Wounds of the Popliteal Artery.
[3] Surgical History of the British Army in the Crimean War, etc., vol. ii. p. 366.
[4] See observations on Incised Wounds of the Tibial Arteries, and of the Arteries of the Foot and Leg.

*Gluteal and Sciatic Arteries.*—Punctured wounds of the *gluteal region* often prove very troublesome and unsatisfactory in their management, because they pierce the *gluteal* or *ischiatic* arteries far down beneath the gluteal muscles, or penetrate the cavity of the pelvis through its notches or foramina, and open the internal iliac artery itself, or one or more of its four or five important branches, within the pelvis. In such cases the surgical diagnosis is always difficult, and often impossible. In such cases, whenever practicable, the wound should be explored by introducing a finger into it for the purpose of locating by the sense of touch the precise point whence the blood issues by jets into the wound. If the punctured artery is found to be external to the pelvis, the bleeding point in it should be laid bare by enlarging and cleansing the wound, and the vessel should be secured by ligatures placed on each side of the aperture. But if it be shown by the occurrence of intra-pelvic extravasation of blood, or by other signs, that the internal iliac artery, or some branch thereof, is wounded within the pelvis, it will be impossible to reach and tie the punctured artery in the wound. Under these circumstances, it sometimes becomes very difficult to decide what plan of treatment should be adopted. One thing, however, ought never to be done: the solution of the perchloride or the persulphate of iron must never be injected into the track of the wound through the gluteal muscles, in order to restrain the bleeding in such cases, because the internal bleeding from the wounded internal iliac artery or branch thereof cannot be restrained thereby, and the presence of these salts of iron in wounds generally does much harm. Under these circumstances, the first thing to be tried, in most cases, is compression. It should be applied to the common iliac artery, and, at the same time, to the wound itself, if possible, with a view to obtain coagulation of the blood in, and obliteration of, the wounded artery. The very *desperateness* of these cases makes it all the more necessary to use the compression faithfully, intelligently, and persistently; otherwise, a traumatic aneurism will form. If we are successful in applying pressure to the common iliac artery, for arresting hemorrhage from the internal iliac artery or its branches, there quickly forms at the mouth of the wounded artery a clot of blood which prevents further hemorrhage; but if the compression be not properly applied, if it be not sufficiently strong, or not continued long enough to obliterate the vessel, the clot quickly becomes detached, and forms a so-called false consecutive aneurism.

The accompanying wood-cut (Fig. 418) shows the arteries of the pelvis, together with the internal epigastric and circumflex iliac, *in situ*.

I cannot better show the extremely grave importance and very difficult nature of these injuries than by relating a few cases that occurred during the late war:—

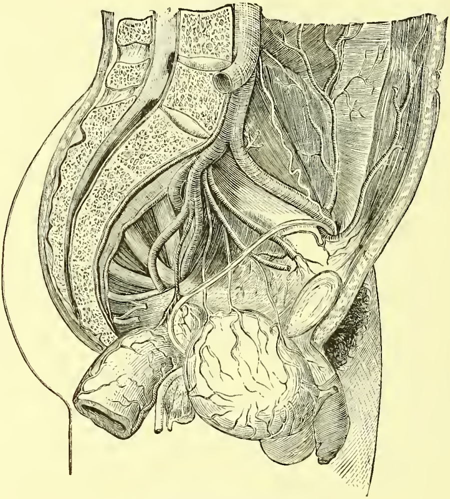
A soldier, aged 24, was wounded in the right buttock, May 9, 1864. He did well, apparently, until June 27, when hemorrhage of an alarming character occurred, and twenty-five ounces of blood were lost. It was checked outwardly by compression, but he sank, and, on the 29th, he died. The *necroscopy* revealed an immense accumulation of blood under the gluteus maximus, and the sac of what had been an immense traumatic aneurism, following a wound of the *ischiatic artery*. Seven additional instances in which this artery was wounded, were reported during the war, all of which proved fatal.[1] Two cases were treated by tying the artery itself, apparently with single proximal ligatures, one case by tying the internal iliac, one case by tying the common iliac, and one case by applying the actual cautery; but all in vain.

*Internal Pudic Artery.*—A soldier, aged 27, received a bayonet wound of the left pelvis, April 25, 1862.

[1] Medical and Surgical History, etc., Second Surgical Vol. pp. 326, 332, 333.

He suffered extreme pain in the left thigh and leg, which swelled largely, and he died on June 27. *Necroscopy.* The point of the bayonet entered the upper part of the left thigh, and passed through the sciatic notch, injuring the sciatic nerve, and wounding the internal pudic artery, whence a false aneurism formed, which became diffused through

Fig. 418.



The arteries of the pelvis.

the whole pelvic cavity, forcing the rectum aside, displacing the sigmoid flexure of the colon, and rendering defecation difficult and painful. The aneurismal cavity held about three quarts of blood.[1] The swelling of the thigh and leg resulted from the pressure on the iliac veins that was exerted by the aneurismal swelling. Four examples of shot-wounds involving this artery were also reported.[2] The outward bleedings were arrested by plugging the wounds with liquor ferri persulph., and applying compresses with bandages, but they all terminated fatally.

*Ilio-Lumbar Artery.*—A soldier, aged 20, received a shot-wound of the right ilium, February 14, 1862.

Hemorrhage from the ilio-lumbar artery occurred on March 4, to the amount of thirty ounces, and recurred, at intervals, until the 24th, when death supervened.[3] Another fatal case of bleeding from this vessel is reported.[4] There were several large hemorrhages.

*Gluteal Artery.*—Illustrations of fatal bleeding from wounds of this artery were unhappily numerous during our late civil war. Thirteen cases were treated by applying compresses and bandages to the wounded part; and only two of them were saved.[5] When the gluteal, the ischiatic, or the internal pudic arteries are wounded exterior to the pelvis, the surgeon must, at all hazards, perform the difficult operation of tying them, on each side of the

[1] Ibid., p. 323. [2] Ibid., pp. 304, 324. [3] Ibid., p. 327.
[4] Ibid., p. 36. [5] Ibid., pp. 327, 328.

bleeding aperture in their walls. In the following instance the gluteal artery was ligated in the wound with success:—

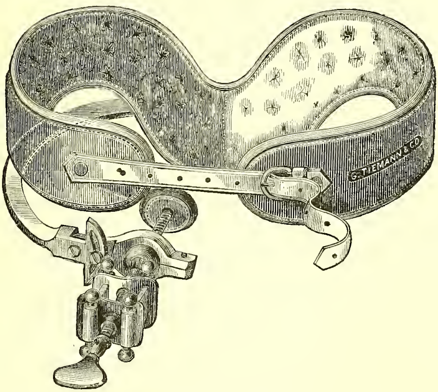
Colonel A. J. Warner received, September 17, 1862, a shot-wound of the right buttock; the missile penetrated deeply and lodged. On February 6, 1863, an operation for its extraction was successfully performed. During the manipulations, however, the gluteal artery was punctured; the hemorrhage immediately became very severe and apparently uncontrollable. "Thrusting my finger to the bottom of the wound," says Dr. J. H. Brinton, "I could readily feel the impulse of the jets of blood. I then requested an assistant to plug the wound with the end of a dry towel. This was done; at the expiration of a few seconds I quickly removed the plug, and while so doing was so fortunate as to see the gaping orifice of the main trunk of the gluteal artery, as that vessel emerged through the great sacro-sciatic foramen. I immediately compressed the trunk with the end of my index finger against the upper bony rim of the notch, thus arresting the hemorrhage instantly and completely. The seizure of the vessel with an artery-forceps and its ligation was then an easy matter. No further hemorrhage, to any extent, occurred; the ligatures separated in due time, and the patient made a happy recovery."[1]

But in the cases where ligation of these arteries cannot be performed, well-adjusted compression must be faithfully applied to the trunk of the common iliac artery, and to the wounded vessel itself; and of these two modes of compression, the former is quite as important as the latter.

Figs. 419 and 420 represent tourniquets for compressing the common iliac artery and the abdominal aorta.

*Internal Epigastric and Circumflex Iliac Arteries.*—These vessels, also, are presented to view in Fig. 418, although it was specially designed for showing

Fig. 419.

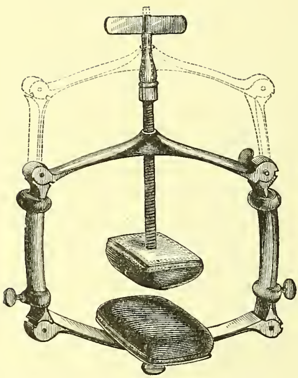



Erichsen's artery compressor.

the arteries of the pelvis. The deep epigastric and circumflex iliac arteries may be opened by simple flesh-wounds of the abdomen, as well as by those which penetrate its cavity, and thus hemorrhages may arise which will prove

[1] Ibid., p. 329.

Fig 420.



Skey's artery compressor.

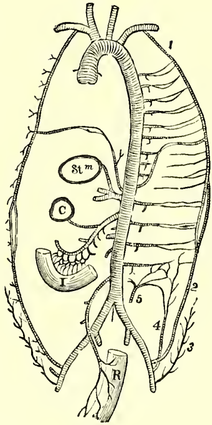
fatal, unless these arteries are seasonably and properly secured with ligatures. During our late civil war, five patients having wounds of the abdominal walls which did not open the abdominal cavity, were destroyed by the hemorrhages which occurred and recurred, in spite of the application of styptics and compresses, until exhaustion and death from loss of blood closed the scene.[1] In four additional cases where the circumflex iliac artery was opened by shot-wounds, the hemorrhages proved fatal, in spite, too, of the application of styptics and compresses.[2] In still another case of hemorrhage from a wound of the abdominal wall, where styptics (Monsel's salt) had been applied again and again without permanently arresting the bleeding, the external iliac artery was tied, but without success.[3] These examples most emphatically teach that wounds of the internal epigastric, circumflex iliac, and lumbar arteries should not be regarded as trivial; but as demanding the rigorous application of the rules for arresting hemorrhage from all wounded arteries of magnitude, viz., exposure of the bleeding aperture to view, and ligation of the artery on each side of it. Moreover, the application of distal ligatures is all the more necessary in these cases, because the terminal branches of the internal epigastric artery are directly continuous with those of the internal mammary, and the terminal branches of the circumflex iliac are directly continuous with those of the iliolumbar artery, as is shown in the accompanying wood-cut (Fig. 421); and, therefore, when proximal ligatures only are put on these arteries, when wounded, there still remains a great liability to the recurrence of hemorrhage from the regurgitation of blood through the distal part of the vessel into the wound, as soon as the blood-pressure is raised high enough by general reaction to expel the coagulum from the distal orifice in the artery.

Boyer speaks forcibly of the importance of ligation for hemorrhage from these wounds, and gives particulars of an instructive case of wound of the internal epigastric artery, that proved fatal, in which this measure had been neglected. Guthrie several times saw this artery tied with success. In the case of a Portuguese soldier stabbed in the belly with a sabre, there was profuse hemorrhage from a small wound made by the point of the weapon. This wound Guthrie enlarged until the wounded but undivided artery became visible; upon this two ligatures were placed, and the external wound was sewed up. The man recovered.[4] In lesions of the abdominal walls, then, when the hemorrhage is severe, and the wound not large enough to allow the bleeding point in the artery to be seen, the surgeon must enlarge the wound until the punctured artery can be seen, and can be secured. We need not fear the hemorrhage as long as such a wound is open and we can place a finger on the bleeding point. But when the surgeon trusts to external pressure, and closes such a wound without securing the punctured artery

[1] Medical and Surgical History, etc., Second Surg. Vol., pp. 9, 10
[2] Ibid., p. 324.
[3] Ibid., p. 10.
[4] Commentaries, etc., p. 510, Am. ed.

itself, then there is abundant cause for anxiety. If these principles be important in hemorrhages of an ordinary character, they are much more important still when applied to the treatment of hemorrhages from the hypogastric, inguinal, and iliac regions. Legouest has twice had occasion to apply ligatures for profuse hemorrhage from flesh-wounds of the abdomen; once to the epigastric, and once to the circumflex iliac artery. Sometimes these vessels, when divided, retract greatly; it then becomes necessary to enlarge the wound considerably, in order to find and tie the bleeding mouths. This is especially apt to happen when the internal epigastric is severed near where it enters the sheath of the rectus. Sometimes, in punctured wounds of the abdominal parietes involving these arteries, the hemorrhage is inter-mural, the blood either escaping into the connective tissue and forming a sanguinolent tumor; or, burrowing between the great muscular and aponeurotic planes, the extravasation becoming widely spread and forming a flattened swelling. In both instances, the wound must be enlarged until the bleeding orifice can be seen and the artery properly tied. When from such extravasations sanguinolent abscesses result, they should be opened by timely incisions, lest there occur inflammation of the contiguous peritoneum, or purulent infiltration of the muscular bundles; the pus, if the operation be delayed, may become widely disseminated.

Fig. 421.




Longitudinal plan of the arteries of the trunk. 1, *Internal mammary*; 2, *Deep epigastric*. They are connected to the aorta by a series of intercostal, lumbar, and diaphragmatic arteries. 3, *Superficial epigastric*; 4, *Circumflex iliac*; 5, *Ilio-lumbar from internal iliac*. The anatomist will notice that it is chiefly the anastomosing branches of the arteries of the wall which are shown. (Struthers, Anat. and Physiol. Obs. Edin. 1854.)

When these arteries are opened by wounds which penetrate the abdominal cavity, and the apertures in the integuments are closed without first securing the wounded vessels, the blood may flow inwardly and collect in great quantity in that cavity; this concealed hemorrhage may be so abundant as to prove fatal.

*Internal Mammary Artery*.—In mere flesh-wounds of the chest, as well as those which extend into its cavity, this vessel may be opened. Moreover, this lesion is not trivial and unimportant, as some surgeons have supposed; for, during our civil war, six cases were reported in which the internal mammary artery was opened, and in all of them the hemorrhage was very profuse, and the issue fatal. Wounds involving this artery, therefore, merit serious attention. Anatomically, the internal mammary is a branch of the subclavian artery, and the first that proceeds from the inferior aspect thereof; it descends behind the clavicle and the costal cartilages, but in close relation with the cartilages, along the front wall of the chest, but external to the pleura, alongside the margin of the sternum and about half an inch therefrom, until the sixth intercostal space is reached; here it divides into the musculo-phrenic and superior epigastric branches, the latter of which enter the sheath of the rectus abdominis, and terminate in or become continuous with the corresponding branches of the internal epigastric artery. The deep mammary arteries (Fig. 421, $_1$) are remarkable for the number of their inosculations and for the distant parts of the arterial system which they serve to connect. They anastomose with each other, and their inosculations, through

the intercostal arteries, etc., with the thoracic aorta, encircle the thorax. On the walls of the chest, their branches connect the axillary and subclavian arteries; on the diaphragm, they form a link in the chain of inosculations between the subclavian artery and the abdominal aorta (see Fig. 421); and in the walls of the abdomen they form anastomoses most remarkable for the remoteness of the vessels which they serve to connect, namely, the arteries of the upper and lower extremities (Harrison). When the aorta becomes narrowed or obliterated, the internal mammary arteries constitute the most important of the collateral channels for conducting blood to the lower extremities. Each of these arteries is attended by two venæ comites.

The hemorrhage in every one of the six cases of wound involving the internal mammary artery, reported during the late civil war, was secondary. In but two of them were ligatures applied. Judson, in one instance, tied the artery, but the method of operating is not stated; the bleeding was arrested, and did not return, but the patient continued to sink, and died six days after the operation from anæmia and traumatic pleuro-pneumonia. Bontecou, in another instance, where there was a so-called seton-wound of the chest, enlarged the wound of entrance, passed a piece of bandage through, and tied it over the ensiform cartilage, ligating the internal mammary artery; the bleeding, however, was not permanently arrested, and the patient died five days afterward from recurrent hemorrhage with pneumonia. Four cases were treated mostly by inserting plugs soaked in styptics, and applying compresses externally, but without benefit, as in the following examples:—

A soldier, aged 20, was wounded June 3, 1864, the ball penetrating at left side of sternum, near junction with second rib, and emerging above clavicle, fracturing both sternum and clavicle. Patient became much reduced from profuseness of suppuration and pleuro-pneumonia. On the 10th, profuse hemorrhage from the external wound occurred, and death followed in twelve hours. Treatment consisted in plugging the wound with lint soaked in liquor ferri persulph. *Necroscopy.* The internal mammary was found in the mutilated tissues with its mouth gaping; no other vessel wounded. Again, a soldier, aged 26, was wounded July 1, 1863, by a conoidal ball which fractured the humerus, passed along the clavicle, and lodged behind the edge of the sternum upon the internal mammary artery. On August 23 this vessel was opened by sloughing, and hemorrhage to the amount of thirty ounces occurred. Cold applications and compresses were applied, but on the next day the patient died. In the remaining two cases the blood flowed inwardly, and accumulated in great quantity, in the pleural cavities.[1]

Secondary hemorrhage from this artery, then, is sometimes hard to detect, and often exceedingly difficult to control, and these results naturally follow its situation on the inner surface of the thorax, and the important offices which it performs in the organism.

No example of primary hemorrhage from the internal mammary artery was reported during the war; still this vessel must, not unfrequently, have been opened by wounds. The conclusion is irresistible that in most instances where this vessel was penetrated by wounds, the victims perished on the field of battle before assistance arrived, while in some instances where the victims survived for a time, the source of bleeding was not detected because the blood flowed inwardly, and the hemorrhage was therefore concealed.

In all stabs, as well as other wounds which cross the track of this artery, the occurrence of hemorrhage from the wound, without the spitting of blood, should lead the surgeon to suspect strongly that this vessel is involved, whereupon he should at once thrust a finger into the wound, and search for the open mouth of the artery, from which he will feel the blood issuing in

[1] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, pp. 523, 524, 548.

jets, if his suspicions be well founded. From the internal mammary artery when wounded, the blood may flow outwardly, or, inwardly, into the anterior mediastinum, into the pleural cavities, and into the pericardium. The hemorrhage from this artery, when wounded, may soon cause death directly from loss of blood and syncope, or indirectly from asphyxia, by compressing the lungs when the blood flows into the pleural cavities, and from paralysis of the heart when the blood flows into the pericardium, so as to compress that organ. But if the external wound be not large enough to admit a finger for exploration, the diagnosis may be very difficult. When such is the case, as well as when the hemorrhage is suspended at the time of examination, anatomical considerations may afford presumptive evidence; and every deep wound near the margin of the sternum, from the first to the seventh rib, when bleeding therefrom, whether external or internal, occurs, should be enlarged, by incisions if necessary, until the bleeding point is brought into view, when a ligature should be applied to the artery on each side of the orifice. Moreover, the distal ligature is needed almost as much as the proximal, on account of the great freedom with which the terminal branches inosculate, as already stated. The artery, too, must be secured by tying it without delay, lest meanwhile there should occur such loss of blood as of itself to prove fatal.

Wounds of the internal mammary artery are often attended with division of the costal cartilages. This complication was present in more than half of the cases collected by Lourdes; and it is almost always present when the vessel is wounded below the fourth rib, particularly when the wound has been inflicted by cutting instruments.

Ligation of this artery is esteemed easy of performance in the first three intercostal spaces, difficult in the fourth, very difficult in the fifth, and almost impossible in the sixth. But when there is an open wound and the contiguous parts are much swollen and discolored by infiltration, or when the artery is much torn and displaced, as sometimes happens in those cases of gunshot fracture of the sternum, etc., which greatly disturb the relations of the parts, the operation of tying this vessel in the wound may become exceedingly difficult in any portion of its course. If the surgeon fail to secure it with ligatures under such circumstances, what then should be done? Baron Larrey, indeed, taught that wounds of this sort should always be closed, and the cure of bleeding left to nature; but there are very serious objections to this plan, which, in effect, leaves the patient to perish directly or indirectly from internal hemorrhage. Nélaton advised that an air-compressor in the form of a bag of India-rubber or gold-beater's skin should be introduced and inflated within the wound, but this instrument is fragile or unreliable at best, and not always at hand or within reach when wanted. It is best, then, to have recourse to the plan of Desault and Zang, and to place over the wound a fine piece of carbolated muslin or carbolated gauze, four or five inches square, pressing the centre of it through the wound into the thoracic cavity, and stuffing the glove-finger or bag thus formed with antiseptic cotton or lint; the angles of the compress are then brought together and tied like a purse, and the pad or ball of antiseptic cotton or lint is drawn gently outward, and made to compress the injured vessel against the sternum. To keep the pad in place, it may be fastened with ligatures to a roller bandage or any other convenient cylinder. The materials for Desault's or Zang's tampon are always at hand, the compress itself can be strongly made and safely applied; and, whenever the attempt to tie the artery in the wound fails, this *tamponing* is the best resource. It is approved by Velpeau and by Otis.[1] At any rate, the hazard of

[1] Op. cit., pp. 525, 549.

exciting inflammation in the pleura and lung by the presence of the tampon in the wound is much less to be dreaded than the danger of hæmothorax.

When the internal mammary artery is injured, the prognosis is always very grave; the risk, too, of secondary hemorrhage is by no means small, as the cases (six), related or referred to above, clearly show.

*Intercostal Arteries.*—These vessels, called specifically the posterior intercostal arteries, arise from the back part of the thoracic aorta, and pass to the intercostal spaces, where, after coming into relation with the intercostal veins lying above and the intercostal nerves lying below, each of them divides into two branches, which run along the borders of the contiguous ribs between the two planes of intercostal muscles, and, finally, anastomose with the anterior intercostal arteries, branches of the internal mammary. The branch corresponding with the lower border of each rib is usually much larger than the other. Posteriorly, the intercostals are quite large vessels, and, coming directly from the main artery of the body, they give rise, when wounded, to profuse and obstinate hemorrhages. During our civil war fifteen such cases were recorded, eleven of which, or 73.33 per cent., proved fatal from hemorrhage; and in one instance the thoracic cavity was found to contain two quarts of blood.

Occasionally, these arteries are opened by stabs or incised wounds of the chest received in affrays; I have known two cases of such incised wounds. In each instance the injured vessel was promptly secured in the wound by ligatures without much difficulty, the chest-wound was then closed, and recovery speedily followed.

Sometimes, too, simple fractures of the ribs are attended with puncture or laceration of these arteries; and when the pleura costalis is also torn in such a way that the effused blood can readily escape into the thoracic cavity, death from concealed hemorrhage may soon ensue, as happened in the following instance:—

An artillery-man was struck, whilst fencing, with a light cane upon the eighth rib of the right side. There was no outward mark of injury, but he became collapsed, and died eight hours afterward. On *autopsy*, the right pleural sac was found to contain about five pints of blood. The eighth rib was found fractured, and a twig of the intercostal artery entering the bone at this point was torn through, while the trunks of the intercostal artery and vein were uninjured.[1]

Most frequently, however, the intercostal arteries are found opened by, or in connection with, fractures of the ribs that are compound; such, for instance, as occur in gunshot-wounds of the chest. The fifteen examples reported in the Surgical History of the War were all cases of wound by gunshot missiles; and the intercostal arteries were injured either by the fragments of comminuted bone, or by the missiles themselves. But gunshot projectiles that are small or minute may open the intercostal arteries without breaking the ribs, and thus cause fatal hemorrhage, as occurred in the following case:—

A young man, aged 15, received a discharge of small shot at forty-eight paces. He instantly fell, but soon got up and ran about six hundred paces, when he again fell exhausted. He was taken home, and died thirty-eight hours after the mishap. *Autopsy.* One shot had penetrated his right chest between the first and second ribs, near the sternum. The right pleural cavity contained twenty-eight ounces of blood. The right lung was compressed to one-fourth of its normal bulk, and wounded. Posteriorly, the shot also had passed through the costal pleura at the inferior border of the sixth rib, about two inches from its head, and had lacerated the intercostal artery. From this wound had issued the fatal hemorrhage (Graefe). Here, too, the wounded vessel had considerable size, for its origin was not far away.

[1] Medical Times and Gazette, Dec. 2, 1860, p. 607.

Injury of the intercostal artery may be predicated in lesions that involve its track, when the wounded person does not spit blood while the symptoms of hemorrhage, internal as well as external, are urgent. If the wound be large, bright-red, but not frothy blood may be seen issuing therefrom; if the wound be probed with a finger, the blood may be felt issuing in jets from the aperture in the artery. When this vessel is lacerated without there being an external wound, and blood flows into the pleural sac, as happened in two instances mentioned above, the symptoms are those of rapidly occurring hæmothorax. Injury of this artery near its origin is always attended with dangerous bleeding. In shot fractures of the ribs it is always of very serious import, from risk of intermediary and secondary, as well as of primary hemorrhage. Of the fifteen cases reported in the "Surgical History of the War," six had primary, five intermediary, and four secondary hemorrhage.

When the intercostal arteries are punctured by stabs, it may be necessary to enlarge the external wound in order to get at and secure the injured vessel with a ligature placed on each side of the puncture. Generally, when the intercostal arteries are opened by external wounds, the hemorrhage should, if possible, be stanched by tying them on this plan; and the efforts of the surgeon should first be directed to the accomplishment of this purpose, meanwhile suppressing the bleeding by applying a finger to the aperture in the vessel whence the blood issues, on the inside of the wound, until the preparations for applying ligatures can be made. Then, still restraining the bleeding with his finger in the wound, the surgeon should extend the wound posteriorly with a scalpel held in the other hand until he lays bare the artery between the two planes of intercostal muscles, and passes round it a ligature of carbolized silk or catgut, on tightening which the hemorrhage from the cardiac side of the wound will be effectually suppressed; the application of a distal ligature completes the operation. When the wound is fresh and the parts sound, no very great difficulty is usually experienced in finding and tying the intercostal artery in the wound itself.

Sometimes, however, when the wound is no longer fresh and the parts are not sound, as, for instance, in secondary hemorrhages, it may be advisable to follow the old method of Gèrard, and include the rib, nerve, and vein in the ligature as well as the artery; it will be still more advisable to do so if the patient has already lost much blood. Restraining, then, at once the bleeding by inserting a finger into the wound so as to compress the open mouth of the artery (an assistant may do it if required), the surgeon should prolong the wound posteriorly in the course of the artery, that is, toward its origin, and taking the blunt-pointed, strongly-curved needle belonging to a chain-saw, or one of the many instruments which have been specially devised for this operation, suitably armed with a ligature of carbolized silk, catgut, or silver wire, he should dip the point of the needle under the lower edge of the rib beneath the artery, and following closely the inner surface of the rib with the blunt point of the instrument, external to the pleura, he should, by depressing the handle or eye of the instrument, make the point appear, covered by the integuments, at the upper margin of the rib. The point should now be uncovered by a small incision, and protruded through it until the ligature can be seized hold of and placed; then the needle should be withdrawn. The ends of the ligature may be disposed of by tying them firmly over a roll of adhesive plaster; or they may be passed through the corresponding holes in a bone or a rubber button of suitable size, and then be firmly drawn and knotted. Another plan of dealing with the ligature is to pass the end which was removed from the eye of the blunt-pointed, strongly-curved needle into the eye of an ordinary good-sized needle and re-insert it through the puncture of the integuments at the upper margin of the rib, carry it between the

integuments and the external surface of the rib, and bring it out of the original wound, where the two ends are crossed, drawn tightly, and knotted. This proceeding is not difficult to execute, and constitutes a subcutaneous ligation of the intercostal artery, vein, nerve, and rib. The upper puncture should be closed with an adhesive strip. With a little care this operation may readily be performed without piercing the costal pleura, as B. Howard has shown.[1] In general, it is well to secure the artery in the same way on the distal side of the wound, as practised by B. Howard. The operation with a blunt-pointed, strongly-curved needle, described above, has one great advantage—the bleeding may be stopped from the first moment of seeing the patient, as it can always be controlled by pressure applied in the wound until the operation is completed. Professor Gross has suggested the drilling of a hole through the rib, and the passing, in this way, of a silver wire around the artery. Whatever plan is followed, care must be taken not to wound the pleura unnecessarily, which can be avoided only by keeping close to the inner surface of the rib, and by thoughtfully manipulating the instrument in other respects. Professor D. H. Agnew's instrument is the best for tying the vessels in with the rib.

Boyer held that lateral pressure was the only remedy for hemorrhages from wounded intercostal arteries. When from any cause ligation cannot be satisfactorily performed, Desault's excellent method of applying lateral pressure to the artery in the wound with a tampon, described above, merits a thorough trial, being equally suited for hemorrhage from the intercostal and for bleeding from the internal mammary arteries. If the pleura and lung be intact, the risk of wounding them is avoided; but if they be already wounded, it is the least irritating dressing that can be employed. There is no danger of dropping the tampon of Desault into the pleural cavity and thus losing it, as has happened in plugging such wounds with sponges or charpie. Moreover, it has proved successful in a considerable number of cases (Bégin, Velpeau, Jamain) in controlling the hemorrhage without exciting inflammation in the pleura or the lung (Otis). In hemorrhage from chest-wounds which open the pleural cavity, the application of compresses externally does no special good; for it directs the flow of blood inwardly, and thus conceals the hemorrhage without abating it.

Guthrie reports one case where secondary bleeding from an intercostal artery recurred several times, and was ultimately suppressed by the oil of turpentine, applied on a dossil of lint, and pressed on the bleeding spot by the fingers of assistants until the hemorrhage ceased; recovery followed. Such styptic solutions, however, as those of the perchloride and persulphate of iron, are not any more applicable to wounds of the chest that are bleeding than they are to wounds of other parts; and when the pleural sac is also opened by the wound, they might do much harm, if applied, by getting into the pleural cavity. So, too, with all the styptic substances which are used in a pulverized state, even those against which, *per se*, valid objections cannot be raised, as they can be against Monsel's salt, etc.: their employment in such cases is hazardous, because they may fall into the pleural cavity. Many other plans of dealing with this exceedingly troublesome form of hemorrhage have been proposed by authors. Some of them are dangerous, others trivial, and others again more ingenious than useful. Inasmuch as bleeding from the intercostal arteries is not unfrequently met with in cases where the pulmonary tissue also is lacerated, the surgeon, in such cases, must avoid doing anything which will increase the hemorrhage from the lung. When, however, an intercostal artery is wounded between the sternum and the middle of the ribs

[1] American Medical Times, vol. vi. p. 52.

—where, perhaps, the majority of wounds of the chest occur—the hemorrhage is not always severe; but the injury of an intercostal artery, towards or near its origin, always causes very dangerous bleeding, and here the vessel is secured with much difficulty on account of its depth. A recollection of these points may assist the surgeon not a little in determining the plan of treatment to be employed.

When the intercostal arteries are lacerated without there being an external wound, and inward bleeding occurs, operative skill is generally powerless to stop it. Guthrie, indeed, suggests, in commenting on a case of this sort, that auscultation would have made known the extravasation, and that relief might have been given by an incision over the spot where the uneasiness was felt; for the loss of blood was not sufficient of itself to destroy life.[1] It is true that, had the spot been known where the artery was injured, in this case, it might have been cut down upon and tied; but it remains to be proved, in future cases, whether auscultation and the sensations of the patient can afford such sure information on this point as would authorize the surgeon to operate. As the symptoms in these cases are usually the symptoms of hæmothorax, so the treatment must, in general, be the treatment of that accident.

## Contused Wounds of Arteries.

The bloodvessels, as well as the integuments, the muscles, and the bones, often suffer from contusions. The "black and blue" spots, called ecchymoses, which appear in all bruises, do so because the capillaries are crushed, and their contents escape. When arteries of some size are mashed by blows, large subtegumentary swellings may form from blood escaping into the connective tissue, of which accident I have seen some notable examples where the temporal and femoral vessels were involved. Large arteries, however, are, in some measure, protected from injury by bruising (1) by their positions, which, generally, are deep and sheltered; (2) by their capacity to flatten readily, which results from the elasticity of their walls and the fluidity of their contents; (3) by the strength of the arterial sheaths and the looseness of the connective tissue which surrounds them, whereby considerable freedom of movement in lateral directions is allowed; and (4) by the prominence of contiguous muscles or other organs which serve to receive or to deflect the vulnerating forces. Contused wounds of arteries may be produced by falls and by blows with blunt instruments; I can call to mind at least two such cases; but the most common cause is injury from gunshot projectiles.

Bruises of bloodvessels, which fall short of crushing them, may nevertheless do great harm. Boyer asserts that the contusion of large arteries is sometimes followed by their rupture and the formation of a diffuse traumatic aneurism; and if the percussion be not great enough to rupture their coats, it will weaken them to such a degree that they will afterwards yield to the impulse of the blood, and form a true aneurism.

Gunshot bruises of arteries which do not directly open them are still attended with ecchymosis of the sheaths. The vasa vasorum, too, are lacerated, and blood may be extravasated between the artery and its sheath in such quantity as to narrow considerably the tube of the vessel. Now, under appropriate treatment, this extravasated blood may be absorbed, the blood-stasis and local irritation may disappear, and the bruised part may be completely restored to a healthy state. But if, on the other hand, there be no treatment at all, or that which is inappropriate, the blood effused in the sheath is

[1] Commentaries, etc., p. 475, Am. ed.

not absorbed, the inflammatory process is lighted up in the bruised part, the tube of the artery is still further narrowed by the occurrence of inflammatory swelling, and occlusion of the artery may follow, with gangrene of the region deriving its supply of nutrient blood from the occluded vessel, as happened in the following instance:—

A soldier was wounded November 27, 1863, by a minié-ball which entered the left thigh, on its antero-exterior surface, six inches below the anterior superior spinous process of the ilium, dipped beneath the integuments and deep fascia, and emerged from its inner surface four inches below the pubes, passing thence into the other thigh. Gangrene of the left foot soon followed. On December 14, the left leg was amputated at the junction of its lower and middle thirds; the artery was controlled during the operation by pressure of the thumb alone; there was very little hemorrhage; the tissues were flabby at the place of section. Pyæmia ensued, and on January 14, 1864, the patient died, on the forty-eighth day after the injury and the thirty-first after amputation.

*Autopsy.*—Both orifices of the wound in the upper part of the left thigh were closed, but the track of the ball was occupied by an abscess containing thin fetid pus. The ball had passed behind the femoral artery, impinging against its sheath, however, and bruising it. At this point the walls of the artery were much thickened, and its calibre lessened one-half. The sheath contained a firm coagulum about one inch long. The specimen was sent to the Army Medical Museum, and is thus described in the Catalogue: "A wet preparation of the upper portion of the left femoral artery, with the walls much thickened by a coagulum in the sheath, following impingement of a ball, which induced diminution of calibre."[1]

To briefly present the points of this case: The missile bruised the femoral vessels without opening their sheath, and the hemorrhagic and inflammatory swelling constricted the tube of the artery very much at the bruised part—so much is certain; it is highly probable also that the coagula which formed in the canal of the femoral artery, where it was inflamed and constricted, were swept onward by the blood-stream, as emboli, into the tibial arteries, and plugged them to such extent as to cause, with the lessened blood-supply from above, gangrene of the foot.

Another preparation belonging to our Army Medical Museum sheds additional light on the same point. It is thus described in the Catalogue: "A wet preparation of the popliteal artery, showing a clot formed in it from inflammation along the track of a ball which did not involve the arterial coats in the sloughing process. Amputation was performed to obviate sphacelus, and the patient recovered."[2] In this example, the ball, in its passage, bruised the popliteal artery; there followed inflammation and occlusion by coagulum of the bruised portion of the vessel; from this arrest of blood-supply, gangrene of the leg ensued.

In a case reported by Guthrie, which belongs to the same category, the ball passed between the femoral artery and vein. The patient died sixteen days after the injury from gangrene of the foot and leg. After death, Mr. Guthrie obtained the specimen. The coats of the artery were not destroyed in substance, although wounded. At this spot the vessel was "much contracted in size, and filled above and below with coagula, which prevented the transmission of blood." The artery was therefore impervious. The coats of the vein were but little injured, although it was "filled by a coagulum and impassable" at the bruised part.[3] In this case, too, the traumatic arteritis caused by the bruise was the chief factor in producing the arterial occlusion.

[1] Catalogue A. M. M., p. 456, Specimen 2114.
[2] Ibid., p. 457, Specimen 2150.
[3] Diseases and Injuries of Arteries, p. 242.

Another case is related in the "Surgical History of the Crimean War:"—

P. Ryan, aged twenty-one, on June 8, received a canister-shot wound (supposed) through the left thigh at its upper part, involving the track of the femoral vessels. On the 16th, gangrene of the foot appeared, and the leg was amputated just below the knee. On the 18th, gangrene attacked the stump; on the 19th, it extended up the thigh; and on the 20th, death occurred. *Autopsy:* "The ball was found to have passed through the thigh internally to the sheath of the femoral vessels, which it had grazed, but not opened. The artery at this point was slightly contracted for a space about an inch in length, but pervious, and containing no coagulum; and, beyond the contraction, its calibre showed no marks of inflammation. The vein, however, was not only also slightly contracted, but its internal surface was inflamed and filled with partially organized lymph, as far up as the entrance of the deep iliac vein, and downward for about two inches from the wound. Its course was thus entirely sealed; but nothing like pus could be found in the femoral or iliac veins, nor in the venous system anywhere."[1] Here gunshot contusion of the femoral vessels caused inflammation with contraction of their walls, and thrombosis with occlusion of their canals; in the artery, however, the blood-clot appears to have been swept into the branches, producing embolism of the same, and consequently, gangrene of the foot, leg, and thigh, in successive stages.

These four examples show very clearly what disastrous consequences may follow the bruising of bloodvessels and their sheaths by the strokes of passing bullets, or by other adequate means. The usual ecchymosis of the bruised part may be attended with hemorrhage into the sheath, compressing and partially occluding the vessel itself; to be followed by inflammation of the walls of the injured vessels with thrombosis, or embolism, and gangrene from arrested blood supply.

But if the extravasated blood be absorbed, and if the inflammatory process be *not* kindled in the bruised vessels, then the obstruction to the circulation may prove but temporary, and complete recovery may eventuate, as happened in the following instance:—

John English, aged twenty, on June 22 received a wound from a musket ball which passed through the thigh. The wound was directly in the course of the femoral vessels. As he was reported to have lost a quantity of arterial blood on receipt of the injury in the trenches, it was feared that the femoral artery had been wounded. The temperature of the limb was sensibly diminished, and the pulsation of the arteries in the foot could not be discerned for several days. The patient was exceedingly restless, and complained of pain and numbness in the calf of the wounded limb. No hemorrhage, however, occurred; the limb regained its natural temperature, and recovery slowly followed.[2]

A widely different and a comparatively frequent type of arterial contusion next claims our attention; a type which is characterized by the occurrence of secondary hemorrhage. Among the consequences of simple contusion that are most to be dreaded, where large arteries are concerned, is ulcerative inflammation and sloughing of the injured vessel. In some of these cases, the bruised fibres of the arterial tunics are too greatly damaged to retain their vitality; hence they must be detached by an ulcerative process which may open the canal of the artery. Contused differ from other wounds chiefly because the stricken part may suffer a loss of vitality, and will have to ulcerate or slough away before any reparation can be effected; inflammation is supposed to be necessary to the consummation of this process. In other instances, a destructive inflammation *per se* is kindled in the bruised vessel, either by the depraved general condition of the patient, or by his unwholesome surroundings, or by bad treatment, which also may open the canal of the artery and cause secondary hemorrhage. I can most clearly, and at

[1] Surgical History of the Crimean War, vol. ii. p. 343. [2] Ibid.

the same time briefly, discuss this important subject by relating a few cases taken from my own note-book and from the "Surgical History" of the late War.

A cavalry-soldier, aged 24, was admitted to Stanton Hospital, under the writer's charge, from the field, June 4, 1864, for a wound of his right leg at the ankle, inflicted by a minié-ball, on May 31. It was resolved to continue the effort, which had already been commenced, to save the limb. On the night of the 7th, arterial hemorrhage from the wound supervened, and about a pint of blood was lost before it was checked. On the morning of the 8th, I amputated the wounded leg, at the place of election, by the flap-method, under sulphuric ether, with but trifling loss of blood, and but little shock; and after the operation the patient's general condition was favorable.

Examination of the amputated member showed that the posterior tibial artery had been grazed by the missile, and that several small bits of bone had been driven into the walls of the artery at this place. The hemorrhage had occurred from ulceration of the bruised part of the artery, and from detachment of the minute fragments of bone that were stuck in it. The ankle-joint was full of purulent matter, the lower end of the tibia was badly comminuted, and the astragalus also was injured by the missile. The patient did well for some time; but thirteen days after the operation he died of pyæmia. In this case, primary amputation ought to have been performed, or the artery ought to have been secured primarily with the ligatures above and below the bruise, because the injury was of such a nature that otherwise secondary hemorrhage was inevitable.

A soldier, aged forty, wounded May 28, 1864, was admitted to Stanton Hospital, under the care of the writer, on June 12. A conoidal ball had passed through the ankle-joint from within outward, in such a way as to involve the track of the posterior tibial artery. On the next morning, while the assistant-surgeon was in the ward, arterial hemorrhage from the wound suddenly occurred, and about three ounces of blood were lost before it was suppressed. I was immediately brought to the patient. There was then no pulsation in the posterior tibial artery at the ankle, while that of the anterior tibial could be distinctly felt. It was evident that the hemorrhage proceeded from the posterior tibial artery. Without delay I had the patient etherized, and I amputated his injured leg in the lower part of its middle third, with but little loss of blood, and with little or no shock.

Examination of the amputated limb showed that the posterior tibial artery had been grazed and contused by the missile; and that it had been opened by exulceration of the bruised portion of its walls, whereby the hemorrhage was caused. The lower end of the tibia, the astragalus, and the os calcis had severally sustained comminuted fracture. The patient died nine days after the operation, apparently from exhaustion; but I believe that he had osteo-myelitis, and that this caused his death. In this case, too, the chance of recovery would have been much increased by primary amputation, or by tying the artery above and below the bruise in the primary period; because the nature of the arterial lesion was such that in the absence of these operative procedures the occurrence of secondary hemorrhage was inevitable, and only a question of time.

A western cavalry soldier was wounded in the neck by a conoidal ball, which entered above the outer third of the right clavicle, and emerged above the middle third of the left clavicle, on July 4, 1864, in a brawl. Simple dressings were applied. Secondary hemorrhage from the common carotid artery occurred on the 11th, which was temporarily controlled by applying liquor ferri persulph.; but, on the 12th, the patient died. The *autopsy* revealed an aperture in the carotid, about two lines in diameter, and about three-fourths of an inch above its origin.[1]

In each of these three cases the hemorrhage was due to the normal separation and detachment of bruised tissues from the walls of an important artery.

There is another form of gunshot contusion of bloodvessels which belongs to the same category, but is much more extensive: "When a limb is crushed

[1] Medical and Surgical History of the War of the Rebellion, First Surg. Vol., p. 412.

by shot or shell, but not carried away, the coats of the artery are often found to remain continuous, and primary hemorrhage to be thus rendered impossible, although their vitality may have been totally destroyed."[1] I have never seen this form of vascular contusion, but still I can readily conceive that it sometimes occurs in those terrible bruises of the extremities which are not unfrequently produced by cannon balls, or bombs, or rifled shells, without breach of the integuments. In such cases the continuity of the bloodvessels is preserved until the dead tissues become separated from the living, for the same reason that the integuments remain unbroken until this time arrives.

The Army Medical Museum at Washington contains a specimen of railway injury, which must be classified under the head of contusions. It is "a wet preparation of the axillary artery, curiously obliterated at the passage of the pectoralis minor. The attached subclavian vein is ruptured. In this subject the humerus and clavicle were comminuted, and the soft parts between the shoulder-joint and the sternum pulpified by being crushed between two cars. No pulsation could be felt at the wrist, and sphacelus from the shoulder to the arm occurred."[2] The patient was admitted to hospital on July 20, and died on the 23d.

Again, contusions of arteries not unfrequently lay the foundation for unhealthy inflammations to open their channels and thus cause secondary hemorrhage, when, but for the occurrence of a destructive inflammation, their walls would have remained intact, as happened in the following instance.

A soldier, aged 28, was wounded at Gettysburg, July 2, 1863, by a minié-ball, which passed through the inner side of his left arm, across the track of the brachial artery, about three inches below the fold of his armpit, without injury to the humerus; and, thence, proceeding to his thorax, made a so-called seton-wound on the left side thereof. He was taken to a general hospital where, after doing well for some time, the bullet-hole in his arm was attacked with a sloughing inflammation which connected the two orifices in an open sore; and on the night of August 3, thirty-two days after the casualty, it opened the brachial artery. Great loss of blood ensued, until a proximal ligature was applied to the artery in the wound. He did well after that, and the wound healed in a short time. On October 16, 1864, when I last saw him, the wounded arm was much atrophied, blue-colored, colder than the sound limb, weak, and much restricted in the range of its movements. There was a large cicatrix on the inner side of his left arm, two or three inches below the armpit. There was a radial pulse in this limb, but it was quite small in volume, and quite feeble in strength. On the 17th, he was discharged from the service for these disabilities, at Stanton Hospital. In this case the bruising of the artery, in all probability, would not have been attended with any serious consequences, had the wound remained free from destructive inflammation; for a month or more elapsed before hemorrhage occurred, and arterial fibres killed by contusion would have separated long before that time.

An example of secondary hemorrhage from a bruised common carotid artery, occurring in a person whose vitality was much lowered by simultaneous injury of the spinal cord, is reported in the "Surgical History of the War."

A soldier received a shot-wound of the neck, January 3, 1863, and was admitted to hospital on the 4th. The missile passed through his neck, dividing the inter-vertebral substance and laying open the spinal cord. He did not seem to suffer much; but, on the night of the 14th, secondary hemorrhage supervened, and before any assistance could be rendered, he lost so much blood that he died on the evening of the 15th. At the *necroscopy* it was found that sloughing of the common carotid artery had taken place.[3]

[1] Surgical History of the British Army in the Crimean War, vol. ii. 340.
[2] Catalogue A. M. M., p. 468, Specimen 1640.
[3] Medical and Surgical History of the War of the Rebellion, First Surg. Vol., p. 412.

Treatment of Contused Wounds of Arteries.—Contused wounds of arteries may be complicated by hemorrhage, the presence of foreign bodies, inflammation, and gangrene. When, from the crushing of arteries by blows, extravasation of blood occurs in large quantity, it may be necessary to ligate the injured vessels in order to suppress the bleeding. If a considerable artery be opened, it must be tied; compression would only increase the irritation already existing. For the treatment of false primitive or consecutive aneurisms arising from this cause, consult the section on Traumatic Aneurism. When the contusion is very severe, and the quantity of extravasated blood very great, and when it collects in a mass in the crushed connective tissue and forms a so-called hæmatoma, the part is commonly black, which might lead us to fear gangrene; but if this blackness disappear on pressure, and if it be soft, and unattended with pain or great swelling, and if the affected parts be still warm, we may conclude that life still exists in them, and that resolution may take place, notwithstanding the collection of blood in the connective tissue. There are many examples of sanguineous tumors (hæmatomata) which have terminated by resolution, after a greater or less time; but it sometimes happens that all of the effused blood cannot be taken up by the absorbents or the veins, and then we are compelled to discharge it by an incision; but such openings are not to be made until we have waited long enough to know that resolution is impossible. To hasten the disappearance of hæmatomata, the application of lead-water generally proves useful; and if much pain be present, the application of lead and opium wash in a warm or tepid state usually brings speedy relief.

Shot-wounds involving the tracks of large bloodvessels must always be the subjects of careful scrutiny and much anxiety on the part of intelligent surgeons, although there may be no bleeding at first. If any sign of considerable injury to the artery itself be discovered on exploring the wound with a finger, if the pulsations be found much weakened in the trunk or branches of the injured vessel below the wound after full reaction, the artery should at once be secured by ligatures applied above and below the bruised part; or, perhaps, the limb should be amputated primarily; otherwise secondary hemorrhage or gangrene is sure to follow, as the cases related above fully prove. But, of course, a bruise on a small spot or portion of an artery may not always diminish the force of the circulation before sloughing; and, in very severe contusions, the canal of the vessel may be closed before sloughing has time to occur. We must not put too much confidence in any one symptom, therefore, but provide, in all suspicious cases, for the contingencies mentioned above.

If it be deemed expedient to treat the case without primary ligation or amputation, we should strive to lessen the risks by abating the inflammation of the bruised part of the artery, but especially that which is ulcerative or phagedenic in character. The wounded part should be kept at perfect rest. The surroundings of the patient should all be of the most wholesome character. The practice of applying poultices with a view to favor the occurrence of suppurative inflammation, is bad in such cases, because it insures suppuration throughout the whole extent of the wound. Carbolated water-dressings (1 to 200) will allow the necessary detachment of the disorganized tissues just as well as poultices, without inducing suppuration in the parts which are disposed to undergo adhesion. Indeed, it is possible for the reparation of the parts lost by the severity of contusion to be effected under such a dressing without the occurrence of suppuration or granulation. The retention of secretions in the wound must be avoided by the thorough use of Chassaignac's drainage tube. The utmost cleanliness should be observed, and all the dressings should be of an antiseptic nature.

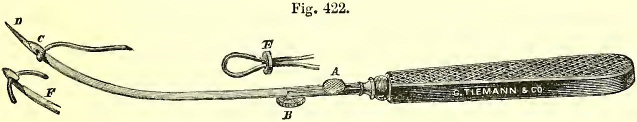
Meanwhile, we should constantly be on the lookout for secondary hemor-

rhage, and the attendants must be told what to do in case it appears, until we can arrive at the bedside of the patient. When secondary hemorrhage occurs, the vessel should generally be secured in the wound by ligatures applied on each side of the bleeding orifice, as was done in the following instance:—

A soldier, aged 19, was wounded on May 28, 1864, by a conoidal ball, which passed through the left axillary space. On June 12, secondary hemorrhage from the axillary artery, to the amount of twenty ounces, occurred. On the 15th, the axillary artery was ligated above and below the wound, under chloroform. The vein was found injured, and was also ligated. The hemorrhage did not recur; but death ensued on the 28th, thirteen days after the operation. The *autopsy* revealed no evidence of phlebitis or pyæmia; and the patient appears to have succumbed to the prostration consequent on the loss of blood prior to the operation.[1]

The axillary artery and vein, in this case, were both opened by ulceration following gunshot contusion, and both vessels were quite properly treated by securing them in the wound with double ligatures. If traumatic gangrene occur, amputation is our sole expedient. If the lesion of the artery be complicated with compound comminuted fracture, and the region involved be the lower extremity, it is sometimes preferable to amputate at once, especially if the knee or ankle joint be opened. When, however, it seems probable that the limb can be saved although the blood-supply derived through the bruised artery be cut off, we may tie the vessel above and below the lesion. Antiseptic dressings and the employment of Chassaignac's drainage-tubes are of great utility in these cases.

Fig. 422.




Drainage-tube carrier of Dr. John B. Hamilton, Surgeon-General of the United States Marine Hospital Service.

To emphasize the necessity which there is for thorough drainage in treating wounds attended with arterial or venous contusions, this figure of a useful instrument is presented.

## Lacerated Wounds and Ruptures of Arteries.

The lacerations and ruptures of the walls of arteries, which claim the attention of surgeons, may be incomplete, as well as complete, in degree; and may occur in either form without the presence of any corresponding external lesions. In those enormous wounds of the extremities which are left behind when the limbs are plucked off by the action of powerful machinery in manufactories, or crushed off by the impact of cannon-balls in war, the arteries are torn completely across, and are often seen hanging out from the raw surface and pulsating quite down to their ragged and contracted ends, which, on examination, are found completely closed by plug-like coagula. When a limb is carried away by a round shot, the principal artery, vein, and nerves will almost invariably be found hanging from the wound, torn off at a point much more distant from the trunk than the remainder of the soft parts; and the end of the artery—lacerated, contused, contracted, and gener-

[1] Medical and Surgical History of the War of the Rebellion, First Surg. Vol., pp. 555, 556.

ally filled, after a very brief interval of time, with coagulated blood for a few lines from its extremity—above that point often pulsates quite strongly, though freely exposed to the air, as in the following instance observed in the Crimean War:—

A man had his left arm torn off at the shoulder-joint. The limb was completely separated from the trunk, too little of the integuments being left to cover the wound. The axillary artery appeared to have bled very little, if at all, at the moment of the injury, and there was no subsequent hemorrhage. The artery and vein were laid bare for full three inches of their course by the laceration; the ends of these vessels for three-quarters of an inch were curved, plugged with coagulum, and tapering to a point; the pulsation of the artery was full to the very base of the plug of coagulum.[1]

Guthrie saw a soldier who had his arm carried away by the bursting of a shell. The axillary artery as it becomes brachial was torn across, and hung down lower than the other divided parts, and pulsated to the very extremity. Pressed and squeezed between his fingers in every way in order to make it bleed, it still resisted every attempt, although apparently by the narrowest possible barrier, which appeared to be at the end of the artery, and formed by its contraction. The canal was marked by a small red point, to which a very slight and thin layer of coagulum adhered, the removal of which, however, did not produce hemorrhage. In another case of like character, Guthrie cut off the end of the artery at less than one-eighth of an inch from the extremity, and then it bled with its usual vigor. In both cases the artery was contracted for that distance, so as to leave little or no canal at its orifice, and what there was was filled by a pin-shaped coagulum.[2]

With a view to illustrate the effects of avulsion on the bloodvessels, Mr. Joseph Bell showed the common femoral artery and vein of a man whose lower extremity had been torn off by machinery. The abdominal cavity was opened and the intestines protruded; but, notwithstanding, he survived thirty hours. The artery and vein were completely occluded by firm coagula, and the external coat was twisted to a fine point at the place of rupture.[3]

But the reader must not infer from these examples that the hemorrhage ceases spontaneously in all cases where limbs are torn off by machinery or by cannon-balls, without the loss of much blood; for such is not the fact. In the largest arteries, such as the common femoral, and occasionally, though much less frequently, in smaller vessels, hæmostasis does not always happen when they are disrupted, unless it is aided by the occurrenee of syncope; and then the hemorrhage often proceeds to such an extent as to prove fatal, as happened in the following instance, which also occurred in the Crimean War:—

A soldier had his leg below the knee carried away by a round shot. He lost much blood before a tourniquet was applied, and was so much collapsed when received at the hospital that an operation was out of the question. The wound was dressed and the tourniquet removed; but he never rallied, and died nine days after the casualty, although no further hemorrhage occurred.[4]

During the progress of our civil war, several cases came to my own knowledge in which the ragged stumps of limbs torn off by cannon-balls or shells bled profusely at the moment of injury, and afterward did not entirely cease to bleed until ligatures were applied. In some of them the loss of blood was so great as to cause a fatal result of itself, although surgical aid was promptly afforded.

When limbs are plucked off from the trunk by machinery, however, as not unfrequently happens in manufactories, there is usually not so much hemor-

[1] Surgical History of the Crimean War, vol. ii. p. 340.
[2] Diseases and Injuries of Arteries, p. 224.
[3] British Medical Journal, January 18, 1873, p. 77.
[4] Op. cit., p. 340.

rhage, a circumstance which probably results from the continuance of the traction of the bloodvessels in the line of their course until they suddenly snap in two, whereupon their ends recoil, incurve, and contract at once, so that little or no blood can escape. Similar cases to that related by Cheselden, of "Samuel Wood, a miller, whose arm with the scapula was torn off from his body,"with but very little hemorrhage, have since been witnessed repeatedly by other respectable authorities in surgery. Dr. Eve has collected three examples of this injury. In each, the arm with the scapula still attached was plucked completely off from the trunk. In each, also, the lesion was produced in substantially the same manner; the subject was caught by the hand or arm in powerful machinery, and then rapidly dragged upward by that member, until the trunk struck a beam, or a ceiling, which suddenly barred its progress, while the limb continued to move onward in the machine. The hemorrhage was not excessive in either case. It is stated that, in one instance, "the artery was seen pulsating at the bottom of the wound, and was plugged up by a coagulum of blood. The vein was distended, and lay on the torn muscles like a gorged leech." But few ligatures were required, and in one case it seems that no vessel was tied, as "there was no hemorrhage" when the surgeon arrived.[1] But little or no sloughing of the lacerated tissues occurred, and each patient made a good recovery.

Dr. F. Katholitzky relates an excellent example:[2]—

A man, aged 37, had his right arm and scapula torn away by being caught in a water-barrel which was being drawn up a shaft by steam power. The limb was found in the water at the bottom of the shaft one hundred and thirteen days afterward. Dr. K. saw the patient one hour and a half after the accident. The wound was about twelve inches long and nine wide, and bled but little. *There was no hemorrhage from the subclavian, nor from any of the arteries, and their ends could not be found in the wound.* There was considerable shock. The wound was reduced by means of steel clamps to the size of a hand, and was covered with charpie. Six hours after the casualty, violent pain set in, but was relieved by the subcutaneous injection of morphia. The wound was dressed with iced compresses. During the following days, there was sloughing of portions of tissue, with moderately high fever. Nothing further of importance occurred during the healing of the wound, which was complete at the end of the seventh week. Two years and five months afterwards the patient was in good health, but right-sided scoliosis had appeared.[3]

But in lacerated wounds, the division of the artery is much oftener found to be incomplete. The Army Medical Museum, at Washington, contains several specimens of this character. One of them was taken from a wound produced by a bayonet-thrust. It shows the subclavian artery torn open for two-thirds of its circumference by the bayonet, one-fourth of an inch from the innominate.[4] It was obtained from an unknown soldier, killed at Fort Wagner, S. C. This specimen proves that when a large artery is wounded by a bayonet, the breach in its walls is not always of the punctured variety. There is another specimen in the same museum which shows the popliteal vessels lacerated by a splinter of wood.[5] This injury was inflicted in a railroad accident, October 29, 1864. The patient entered hospital on November 2, and died on the 3d. His thigh was amputated at the junction of the lower and middle thirds. Abernethy relates the case of a man gored in the neck by the horn of a cow. Hemorrhage came on, and was immediately arrested by tying the common carotid artery; but the patient died about thirty hours after

[1] Eve's Surgical Cases, p. 579.

[2] Allgemeine Wiener med. Zeitung, No. 45, 1873, and New Sydenham Society's Retrospect, 1873–4, p. 278.

[3] [Fourteen cases of this injury are referred to in the Article on Amputations, vol. i. p. 648.]

[4] See Catalogue A. M. M., Specimen 2721.

[5] Ibid., Specimen 3761.

the operation, it was said from inflammation of the brain. On autopsy, the internal carotid artery was found partly torn across, and the primary branches of the external carotid were found separated from the trunk.[1]

Incomplete lacerations of arteries, however, of quite another sort, occur not unfrequently, and, at the same time, are very interesting to surgeons. In these cases the inner and middle coats are torn, while the external tunic remains intact. The lacerated layers of the artery curl backward upon themselves, and may thus completely close the channel of the artery, as happened in the following instance, reported by Professor Verneuil:[2]—

A man, aged 46, after being thrown from a cart, presented the symptoms of violent delirium, right hemiplegia, and cerebral compression. Externally, only numerous contusions could be found. He died fifteen days subsequently. The autopsy showed complete rupture of the inner and middle coats of the left internal carotid artery, with a clot in its canal extending into the branches of the Sylvian artery. There was extreme softening of almost the whole middle lobe of the left cerebral hemisphere.

In these cases, the lacerated inner and middle coats behave in a manner strictly analogous to that which we have shown above to obtain when these same coats are divided by the pressure of ligatures applied in tying arteries, or by the operation of Dr. Speir's instrument for constricting arteries. In other words, the inner and middle coats of arteries may be torn through by accidents, while the external coat remains entire. In such cases the severed coats curl backward, or recurve upon themselves, exactly as they do in the operation of constriction or crushing of arteries performed with Dr. Speir's instrument for the suppression of hemorrhage, described above (see Fig. 395); and, by their recurvation, these coats may entirely close the lumen of the injured artery.

Again, when in such cases of incomplete laceration of arteries, the recurvation of the inner and middle coats does not suffice to block up the channel of the injured vessel, the pressure of the blood is liable to stretch the outer coat at the place of injury, and expand it into an aneurismal sac, thus furnishing a very interesting variety of traumatic aneurism, as happened in an example recorded by Mr. T. P. Pick,[3] in which there was a rupture of the inner and middle coats of the femoral artery, caused by a strain, and followed by a gradual dilatation of the outer coat, and the formation of a traumatic aneurism. Gangrene of the limb set in, and the patient died shortly after amputation at the hip-joint. Digital compression had been previously tried for the cure of the aneurism, and, for a time, with apparent success.

Treatment.—In cases where a limb has been torn or plucked completely off from the trunk by the action of machinery, it is generally expedient to tie the principal vessels on the face of the stump. The arteries that project above the surface, or hang out, should always be secured by ligating them with carbolized catgut, whether they bleed or not when the surgeon arrives. The integuments should then be drawn together, and the case treated as an incised wound. A good result has not unfrequently been obtained in these cases by this plan of treatment. As a rule, no tissue is cast off by sloughing or by ulceration, unless it has happened to be badly bruised by striking against some solid body—for instance, a ceiling or a beam.

When a limb has been struck off by a cannon-ball, or a bomb, or any other form of shell, and thus its bloodvessels have been torn in two, it is always advisable to amputate the member at some higher point, if practicable; for

[1] Surgical Observations, vol. ii. p. 72, Am. ed.

[2] Bull. de l'Acad. de Méd., Jan. 1871; and New Sydenham Society's Retrospect, 1871–2, p. 84.

[3] St. George's Hospital Reports, vol. vi. p. 161.

the tissues of the limb are likely to be torn and bruised, or disintegrated and infiltrated with blood, to some distance above the breach, as I once found on examining the ragged-looking stump of a forearm that had been stricken almost off by the premature discharge of a cannon. The tissues of this stump appeared to be but slightly injured, away from the wounded surface, until they were cut into, when they were found to be ecchymosed and disintegrated, as stated above, nearly up to the elbow-joint. The amputation was therefore performed above the elbow, in the continuity of the arm.

Hemorrhage from lacerated wounds that are caused by bayonets, by splinters of wood, by the horns of infuriated animals, or by other means, should in general be restrained by compression until the lacerated vessel itself can be brought into view by making incisions, etc., when it should be tied with carbolized catgut above and below the aperture in its tunics. It should also be divided midway between the two ligatures. When, however, it is impracticable to tie the bleeding vessels at the laceration, the artery from which it springs should be ligated as near the wound as possible. Again, when the parts surrounding the breach are damaged in such a way as to put the preservation of the limb out of the question, or when the peculiar nature or great extent of the injury renders the salvation of the limb impossible, amputation should immediately be performed.

Gangrene of the extremities, when caused by the laceration of arteries, demands that recourse should be had to amputation without delay. When gangrene attacks the toes because the popliteal artery is occluded by the recurvation of its torn inner and middle coats, or because it is torn completely across, the operation should be performed at the knee-joint. When the femoral artery is the seat of the laceration, the operation should generally be performed high up in the thigh, but without permitting any delay to occur in either case. When gangrene attacks the fingers because the axillary artery is torn, the limb should forthwith be amputated near the shoulder.

Aneurisms caused by the laceration of arteries should in general be treated by laying them freely open, scooping out the clots, finding the orifice, and ligating the artery above and below the opening with carbolized catgut, dividing the vessel also midway between the two ligatures. In the after-treatment, antiseptic dressings and drainage-tubes should be employed.

Ruptures of Special Arteries.—*Femoral Artery.*—The main artery of the lower extremity is rent asunder without external wound much oftener than many suppose. In the following example the common femoral artery was ruptured by a strong blow:—

A robust young man, an iron-planer, aged 23, was admitted to hospital, on October 15, with an abrasion of the right groin, and a corresponding swelling of great size which extended upward almost to the umbilicus and downward to the lower third of the thigh. There was no pulsation in the tumor nor in the tibial arteries. He was evidently suffering from extreme loss of blood, being very pallid, and his radial pulse barely perceptible. His injury resulted, half an hour before admission, from being driven by a plane which struck his buttock whilst reversing, and drove him over the "cheek-piece." He was so low that no operative procedure was admissible, and early next morning he died. *Necroscopy* thirty hours after death. The swelling was due to an immense extravasation of blood. The common femoral artery was found completely severed just below Poupart's ligament; its proximal end was filled with a conical clot; its distal end had the external coat tightly twisted beyond the retracted inner and middle coats. Coagulated blood was found in the sheath of the artery up to the common iliac and down to Hunter's canal. The femoral vein contained a clot opposite the place of rupture. The adductor longus and pectineus muscles were also torn across.

Beneath the fascia there was an extensive coagulum which spread in the thigh through the intermuscular spaces to the back of the limb.[1]

The cause of death appears to have been "shock," and an extensive hemorrhage from the ruptured femoral artery which was hidden from view by the integuments, but mainly the latter.

The next example shows that the femoral artery and vein may both be torn across when pressed upon by a heavy weight without any corresponding fracture or any perceptible breach of the integuments:—

A man, aged 50, had one wheel of a cart loaded with manure pass over his right thigh. Half an hour afterward he was brought to University College Hospital in a state of extreme collapse; the limb was much swollen and very tense to above the middle of the thigh; foot cold, with motion and sensation in it lost; no pulsation in the tibial arteries. There were scarcely any bruises visible, and the bone was uninjured. Next morning the limb was very livid. There was no increase in the circumference, but the extravasation extended somewhat higher on the inner side. There was no pulsation nor bruit in the swelling. The limb was amputated about two inches below the trochanter; but the patient sank and died soon after the operation. On dissecting the ablated member, all the intermuscular septa were found distended with coagula. On the inner side of the limb, above the popliteal space, there was a large pulpy cavity in which the femoral artery and vein were both found torn completely across; both were plugged by firm coagula at each end. The artery was much contracted for two inches above the rupture, and its torn end was nearly closed thereby. The artery was also atheromatous, and slightly calcified here and there.[2]

In the following instance there was a rupture involving all the coats of the left femoral artery; but it was cut down upon, the clots were turned out, and both ends were secured by catgut ligatures, with a good result:—

The subject was a collier, aged 30, a patient at the Manchester Royal Infirmary, whose case is reported in the British Medical Journal for August 8, 1874. He ruptured his left femoral artery while straining at his work. He was admitted with a large, diffused, non-pulsatile swelling in the upper part of his left thigh, and no pulsation in the arteries of his leg. From the history of the case, and the condition of the limb, a diagnosis of rupture of the femoral artery was made. Lister's aortic tourniquet was applied, an incision over Scarpa's triangle was made, a large quantity of coagulated blood was removed, and the divided ends of the artery were seen and secured by catgut ligatures. The man progressed uninterruptedly to recovery.

The proper thing to do in cases such as these would therefore seem to be to restrain the inward effusion of blood as soon as possible by digital compression, or by the application of a tourniquet, or Esmarch's elastic ligature, until the seat of the rupture can be laid open by incisions, the clots turned out, and both ends of the artery found and securely tied with prepared catgut. The wound should also receive antiseptic treatment. But, in most cases, the timely restraint of the extravasation of blood into the connective tissue of the limb is a matter of paramount importance; for, if this effusion be not soon suppressed, the patient may perish directly from loss of blood, as happened in two instances related above.

The inner and middle coats of the femoral artery are sometimes lacerated by a blow upon the thigh, whereupon a femoral aneurism ensues from dilatation of the external tunic. Mr. Home has reported the following case which was under the care of Mr. Birch, at St. Thomas's Hospital:—

John Lewis, a negro, received a blow on the anterior part of his right thigh. About a month afterward he perceived a small tumor, which increased; his own expression was that he could feel it *thump, thump*. The tumor appears to have rapidly enlarged.

[1] British Medical Journal, November 22, 1873, p. 603.
[2] Ibid., July 30, 1870, p. 116.

He therefore came to London, and entered the hospital, Oct. 26. On examination Mr. Birch found a large pulsating tumor in the femoral region, extending upward to within less than two inches of Poupart's ligament, and occupying two-thirds of the thigh; it was without doubt a femoral aneurism. On Nov. 3, Mr. Birch tied the femoral artery half-an-inch below the profunda; pulsation in the tumor immediately ceased. Gangrene of the sac, however, supervened. On Nov. 14, the tumor burst, and discharged serum and grumous blood; the patient died, in the evening, from septicæmia and secondary hemorrhage. *Autopsy.* The integuments at the middle of the tumor were mortified. The blood contained in the tumor was very putrid. Water injected by the external iliac artery escaped freely from the wound of operation, at the ligature, where the artery appeared to have been opened by ulceration. The laceration of the inner and middle coats from the blow had occurred two and one-half inches below the origin of the profunda. The arterial tunics did not exhibit atheroma or calcification, or any structural degeneration. "The opening where the artery passed out of the aneurismal sac was nearly three inches below the part where it entered."[1]

The sac of this aneurism appears to have consisted of the external tunic of the artery, widely dilated, and strengthened externally by adherent laminæ of connective tissue.

Another interesting example seems to have been taken from Clarke:—

A man, aged 48, entering hurriedly a badly lighted chamber, struck his left groin with great force against the corner of a table. Ten days afterward, a small tumor, of the size of a pigeon's egg, and at first taken for an enlarged lymphatic gland, appeared at the point contused. This tumor, in three nights, acquired an enormous size; and it pulsated so strongly as to raise the bed-clothes. The tumor sloughed, and burst open, but without hemorrhage. The patient was in the way of cure, when he succumbed to pneumonia. The artery had been torn across.[2]

In this case the aneurismal swelling, which was formed at first by the gradual expansion or dilatation of the external tunic of the femoral artery at the point where its inner and middle coats had been ruptured by striking against the corner of a table, suddenly gave way without apparent cause; and, in consequence, an enormous swelling, or a so-called diffuse aneurism, soon appeared, from the extravasation of blood into the connective tissue of the thigh; this in turn suppurated and was opened by ulceration or sloughing, but without the occurrence of hemorrhage; the man, however, ultimately died of pyæmic pneumonia.

*External Circumflex.*—The following case, in which the *external circumflex artery* of the right thigh was ruptured, was under Dupuytren's care at the Hôtel-Dieu; it will prove, from its resemblance to the last in several particulars, of much interest in this connection:—

A man, aged 46, a cook, in running round a table in the kitchen, struck the outer and upper part of his right thigh against an angle of the table. Pain, at the moment of injury, was very acute; twelve days afterward, a swelling of the thigh suddenly rose up (in the space of ten minutes). Leeches and resolvent cataplasms were applied. Subsequently the swelling lessened or increased according to his exact observance of quietude or the reverse. A physician, deceived by the absence of pulsation, made an incision therein two inches long; red blood and coagula were discharged. The wound was immediately closed, and the patient entered the Hôtel-Dieu on November 30. The right thigh presented a tumor which occupied its external and anterior region. The skin over it was rather leaden-hued; there was irregular fluctuation in it, and complete absence of pulsation. The femoral artery and the dorsalis pedis beat normally. Dupuytren announced that the swelling had resulted from the rupture of small vessels, caused by the blow received on the thigh. Diet and resolvents were prescribed. A

[1] The London Medical Journal, 1786, p. 391.

[2] Nouveau Dictionnaire de Méd. et de Chirurg. pratiques, t. x. p. 471. Paris, 1872.

compressor, however, was kept ready to suppress any hemorrhage that might supervene. December 4, towards evening, two cupfuls of red blood flowed out; the compressor was placed on the femoral artery, and arrested the hemorrhage; five days later it was removed; pus mixed with blood and containing clots was discharged from the wound. December 19, some spoonfuls of blood escaped; there was also mild delirium. December 22, death occurred.[1] At the *autopsy*, a vast cavity containing extravasated blood was found. The external circumflex artery had been ruptured.[1]

*Rupture of the Popliteal Artery.*—This vessel, notwithstanding its sheltered position in the flexure of the knee, not unfrequently sustains a traumatic lesion in the shape of rupture. In the following example the popliteal artery was partially, and the popliteal vein completely, torn across, without external wound:—

A healthy young man, aged 19, while riding on the front seat of an omnibus, was struck on his left knee by the top of a cart drawn by a runaway horse, which drove his knee backward with great force. On admission to hospital, soon afterward, there was much contusion of the knee observed, with swelling in the popliteal space, but no sign of fracture nor of dislocation. The swelling increased, and the patient complained of loss of sensation in his leg; the temperature of the leg also fell, and pulsation could barely be felt in the posterior tibial artery. On auscultation a low clicking sound was heard in the course of the popliteal artery. The diagnosis was a probable rupture of that artery. Primary amputation above the knee was resorted to, and the patient ultimately did well. On examination, there was found extensive effusion of blood into the areolar tissue of the amputated member; the popliteal vein was completely severed; and the inner and middle coats of the popliteal artery were torn through and separated from the external coat, which remained undivided.[2]

The injury of the knee-joint which complicated the case, and the gangrene of the leg which was strongly threatened, necessitated the performance of amputation. However, if that operation could have been avoided, and the limb saved, a popliteal aneurism would, doubtless, have resulted from this lesion of the artery; and I believe that a similar lesion of the inner and middle coats of this artery, caused by violent stretchings as well as by blows, not unfrequently gives rise to popliteal aneurism, especially when that affection occurs in young persons who have neither atheroma nor calcification in the walls of any bloodvessel. The following case illustrates this point:—

On March 25, 1869, I was called to a young man, aged about 21, of healthy parentage, healthy constitution, and good habits, on account of a popliteal aneurism which had returned several months after being apparently cured by ligature of the superficial femoral artery. The origin of the aneurism could be attributed to nothing but a severe strain, which had probably ruptured the inner and middle coats of the popliteal artery. Flexion treatment had been employed in the summer of 1868, but without benefit; in the autumn, ligature of the femoral had been performed with apparently an excellent result. Early in March, however, the disease had returned; the tumor had increased rapidly. On the 25th, when I was called, it was considerably more than half as large as my fist, and the pain was intense; all the signs peculiar to aneurism were present. Notwithstanding confinement to bed, etc., the tumor continued to increase with great rapidity. His home did not permit of operative treatment, and as the speedy employment of operative measures was imperative, on account of the great size and rapid growth of the swelling, I had him sent to St. Luke's Hospital, on April 12, just nineteen days after I first saw him. There, compression of the femoral artery, both digital and instrumental, was faithfully tried, but without success. The aneurism then appeared almost ready to burst; and, as a last expedient, amputation was performed. He did well for some time; but pyæmia supervened, and, on May 9, caused his death.

[1] Nouveau Dictionnaire de Méd. et de Chirurg. pratiques, t. x. pp. 467, 468.
[2] British Medical Journal, August 28, 1875, p. 259.

A case of popliteal aneurism, operated on by Mr. James Earle, at St. Bartholomew's Hospital, was also caused by a strain:—

John Smith, aged about 50; he said that about six months before, he had fallen from a scaffold, and that his leg had been caught between the rounds of a ladder, which broke his fall; that he immediately felt pain in the upper part of his leg; that soon afterward it began to swell, and that the swelling had gradually increased to its present size. On examination there appeared a large hard swelling under the heads of the gastrocnemii muscles, reaching up to the bend of the leg. Pulsation was plainly felt in it, and there was no doubt of its being an aneurism. The tumor was now increasing very fast. January 28, 1792, Mr. Earle tied the artery a short distance above the tumor, on Anel's plan; the ligature came away on the fifteenth day, and the man made a good recovery. The case was communicated by Mr. Earle to Home, who published it in the London Medical Gazette. I believe that the violent stretching to which the popliteal artery had been subjected in this case ruptured its inner and middle coats, and thus caused the development of an aneurism.

*Rupture of the Anterior Tibial Artery.*—In the following example, this vessel was burst open by a blow from a spade, without any corresponding breach of the integuments:—

A laboring man had noticed a slight swelling on his ankle, which gave him no pain, until he struck it a severe blow with a spade one day while at work. Afterward the swelling gradually and continuously enlarged. An explorative incision gave issue only to blood. On operating for the removal of this swelling, it was found to be caused by a wound of the anterior tibial artery, which communicated with an old bursal cyst.[1]

By severe blows and by violent strains the posterior tibial artery may be ruptured, just as readily as the anterior tibial, the popliteal, or the femoral; and the treatment should generally consist of bringing into view, by suitable incisions, etc., the ends of the ruptured artery, and securely tying both of them with ligatures of prepared catgut, unless there be some complication present which necessitates amputation.

*Rupture of the Brachial Artery.*—Malgaigne relates the following case:—

M. Michaux received at the hospital of Louvain a lad of ten years, who had dislocated his elbow backward and outward. There was considerable swelling, but the radial pulse still continued to beat. On the next day reduction was attempted, with assistants. On the third day it was again unsuccessfully attempted; and, in consequence, the elbow became greatly swollen, the radial and ulnar arteries ceased to beat, and the hand lost all color and sensibility. Gangrene ensued; and, six days after the last attempt, M. Michaux performed amputation which saved the patient's life. Examination of the amputated limb showed a rupture of the brachial artery and median nerve.[2]

The case of a lad, aged 18, who had compound dislocation of the elbow and rupture of the brachial artery, but still recovered, is reported in the Lancet of August 8, 1874. The articular surface of the lower end of the humerus protruded through a lacerated wound at the front and inner part of the forearm. The brachial artery was found to be torn across. The case progressed favorably without interruption. At the end of eight weeks the patient was sent into the country with the wound healed, and the elbow anchylosed at a convenient angle.

In the museum of St. Bartholomew's Hospital, Series XIII. 88, there is part of a brachial artery which was torn straight across by external violence. The patient, aged 69, fell with his arm stretched out. At first he seemed little injured; but pulsation was lost in the radial and ulnar arteries. In a few hours the arm became enormously swollen and livid, and amputation near the shoulder was performed.[3]

[1] British Medical Journal, January 11, 1873, p. 43.
[2] Traité des Fractures, etc., t. ii. p. 153.
[3] St. Bartholomew's Hospital Reports, vol. ii. p. 107.

Pelletan reports the case of Nicolas Pochard, a young soldier, who, from practising the manual of arms with the zeal of a young soldier, acquired an aneurism of the left brachial artery, which was caused by blows or contusions received from the lock of his gun, that were very often repeated until the tunics of the artery gave way.[1]

*Rupture of the Axillary Artery.*—Many examples of this lesion, without any corresponding breach of the integuments, have been placed on record. This accident is very serious, for more than two-thirds of the reported cases have proved fatal. Moreover, it has been produced in many different ways, the most important of which I shall briefly refer to or describe.

Pelletan relates the case of Gabriel Longpré, a journeyman mason, aged about 40, whose axillary artery gave way so that an aneurism formed, in consequence of the violent stretchings to which he subjected it in suspending himself, with all the weight of his body, by the hands, from the pegs of his scaffoldings, from time to time, in order to alleviate the pains of rheumatism.[2] This case proved fatal.

Mott reports the case of Wm. Haines, aged 28, whom he found, on examination, to have an aneurism of the right axillary artery, as large as a goose's egg, with the following history: "About seven weeks before, he received a violent strain while carrying a canoe on hand-bars across the arms, which was followed by an extensive discoloration of the skin of the right arm, extending to the chest, and attended with considerable pain. Three weeks subsequent to the accident he observed a small swelling, about the size of a pigeon's egg, under the right arm, which had rapidly increased." Mott tied the subclavian artery above the clavicle. The man made an excellent recovery.[3]

In the museum of the Royal College of Surgeons, Series XXV. 1695, there is an axillary aneurism which was caused by rupture of the axillary artery, from the falling of a man on ice with his arm extended.[4]

Inspector-General Smart, R. N., has called attention to the fact that the axillary artery may be so much injured by the sudden and violent wrench of the shoulder which gunners sustain when explosions occur while in the act of loading cannon, that gangrene of the limb ensues from the occlusion of that vessel. He has also reported three cases in point.[5] They all occurred from explosions while in the act of ramming home, by which the rammer was expelled, and the arm employed in loading was violently extended. In such cases the artery is injured by the forcible extension of the arm, without puncture or laceration of the integuments.

The injury sustained by the artery often consists of rupturing its inner and middle coats, which then recurve and close the lumen of the artery, whereupon gangrene soon results. Dr. Smart points out that when gangrene appears in such cases, amputation near the shoulder, performed without delay, is the only expedient that can save the patient.

Similar cases of injury of the axillary artery from strains and blows, without any external wound, have been mentioned by Aston Key, Le Gros Clark, Liston, Syme, and Gibbs. Such cases with many interesting examples of various accidents belonging to the same category have been collected and arranged in two tables, by Eug. Boeckel, in the "Nouveau Dictionnaire de Médecine et de Chirurgie Pratiques," in the Article *Axillaires* (*vaisseaux*), t. iv. pp. 365–9, and 370–74. Paris, 1866.

In the following example, the axillary artery was ruptured by passive movements made for the relief of false anchylosis:—

A woman, aged 40–45, of rather feeble health, had her left shoulder-joint completely stiffened by rheumatic inflammation. On January 10, 1858, about half an hour

[1] Clinique Chirurgicale, t. ii. pp. 14, 15. [2] Op. cit., t. ii. pp. 49, 50.
[3] American Journal of the Medical Sciences, vol. vii. 1830, pp. 309–11.
[4] St. Bartholomew's Hospital Reports, vol. ii. p. 107.
[5] British Medical Journal, September 23, 1871, pp. 342, 343.

after some unusual efforts in the way of passive motion, there came great swelling in and about the axilla, which increased and extended by degrees about the shoulder and upper half of the arm. On January 19, Sir James Paget saw her. She looked pale, feeble, and reduced by the pain. The whole axilla was distended as much as the fixed position of the shoulder would allow, with a tense, firm swelling, raising up in front the pectoralis major, and still more prominently behind the teres major and latissimus dorsi. Pulsation was distinctly felt in every part of this swelling. A rough, blowing sound was heard all over it, and for a little distance above and below. No pulsation was discernible in the brachial artery or its branches. Pressure on the main trunk above the aneurism abolished the pulsation and bruit. Complete rest, diminished food, and anodynes were recommended, and the policy of delay was continued until April 23, when the increased size of the tumor and other symptoms made an operation imperative. Sir James Paget opened the tumor, under chloroform, by cutting just behind and parallel to the pectoralis major the whole length of the axilla, and by making a second cut at right angles with this, commencing at its middle, through the pectoralis major muscle, straight upward, its whole width. Raising the angular flaps of the ⊥ shaped wound of operation, the surface of the great mass of the clot was exposed. Two small arteries that were cut were tied. The clots were scooped out and an oval-shaped aperture one-fourth of an inch long by one-tenth of an inch wide was found in the posterior wall of the axillary artery. Above and below it the vessel appeared sound. Ligatures were applied above and below the aperture, and the vessel itself was divided between them. The loss of blood during the operation was under six ounces. The cavity of this aneurism was the anatomical axilla exactly filled and distended. The patient made a good recovery.[1] I have taken space to give all the steps of this important operation, and almost any surgeon who is about to undertake its performance will concede the value of Sir James Paget's method, and probably wish for greater fulness of detail.

Dislocation of the arm at the shoulder-joint is sometimes attended by rupture of the axillary artery, without any external wound. In other words, the same force that displaces the head of the humerus, rends the accompanying artery also, as happened in the following instance related by Dr. R. Adams:—[2]

John Smith, aged 50, was thrown down by a runaway horse. About ten minutes afterward he was brought to the Jervis Street Hospital "in a cold perspiration, pallid, and apparently on the verge of syncope." The left humerus was found to be dislocated into the axilla. The artery accompanying it was also ruptured; blood was extravasated into the axilla, and there was corresponding tumefaction or diffused aneurism; no pulse in radial and ulnar arteries. Dr. Adams easily reduced the dislocation, which he proceeded to do at once, while the man was still prostrated by the "shock," and by the concealed hemorrhage. Ten days later, Mr. O'Reilly tied the subclavian artery. The man recovered and lived many years.

Nélaton states that, although rupture of the axillary artery in consequence of dislocation of the shoulder is very rare, he has observed a remarkable example, attending a displacement below the glenoid cavity. The two inner tunics of this vessel were torn to a very small extent; a false aneurism resulted, that grew rapidly, and obliged him, three months later, to resort to ligation of the subclavian artery, which he practised above the clavicle; but the disorder had already made so alarming a progress that, notwithstanding the ligation, the aneurismal cyst burst open, and entailed a sad termination from secondary hemorrhage.[3] Elsewhere, I find it stated that the patient was a woman, advanced in years; that the aneurism communicated with the cavity of the joint; and that the reduction was easily effected. From the last-mentioned circumstance, Nélaton probably inferred that the laceration

[1] St. Bartholomew's Hosp. Reports, vol. ii. pp. 103–106.
[2] Cyclopædia of Anatomy and Physiology, article "Shoulder-joint," pp. 616, 617.
[3] Élémens de Pathologie Chirurgicale, t. ii. p. 368.

of the artery occurred in connection with the displacement of the caput humeri, just as it did in Dr. Adams's case, related above.

Professor A. Bérard has observed in connection with a dislocation of the humerus under the coracoid process, a rupture of the two inner tunics of the axillary artery, extending through its whole circumference; the external tunic was stretched out as a slender tube. This lesion was attended by obliteration of the vessel, and gangrene of several fingers, and, finally, by the death of the patient. The absence of pulsation in the radial and ulnar arteries made M. Bérard suspect a lesion of the axillary artery.[1] In this case, doubtless the ruptured inner and middle coats recurved, so as to close the channel of the artery.

Moreover, Malgaigne has shown that rupture of the axillary artery has occurred in connection with most of the common forms of dislocation at the shoulder.

In some cases, however, where dislocation of the humerus has been thought to be present, the axillary artery has been found torn by the splinters or fragments attending a fracture of the humerus, there being no dislocation whatever of that bone. The following examples in point have occurred in the practice of two very eminent surgeons:—

A man fell and injured his shoulder. The surgeon who first saw him said there was a dislocation, and tried to reduce it. Being not quite satisfied with the result, for the head of the humerus still appeared to project in front more than it ought to do, he sent for Mr. Stanley, who thought it might be a case of partial dislocation forward (much spoken of at the time by Mr. Abernethy). Accordingly, they bound the arm tightly across the chest, with the hand resting on the opposite shoulder. Calling a few days afterward, Mr. Stanley's attention was aroused by the fact that there was no pulse at the wrist of the injured arm. The bandage was immediately removed, but without restoration of the pulse. Many years later, the man died, and Mr. Stanley carefully examined the part. He found that there had been a fracture through the anatomical neck of the humerus, with obliteration of the axillary artery opposite thereto.[2] Mr. Callender, in commenting on this case, fancies that the inner and middle coats of the artery only had given way, as in Bérard's case, which I have just presented—where, however, the obliteration of the artery was followed by death from gangrene; and his view of the case is probably the correct one.

Mr. Skey[3] met with the next example: A woman, aged 55, slipped in walking, and fell violently to the ground, with her arm in an extended position. A day or two afterward she was seen by a surgeon, who detected and reduced, it was said, a dislocation of the shoulder. Three or four weeks after that, she began to complain of a swelling in the armpit, which appears to have slowly increased. Two months later, some blood escaped. Then she was sent to St. Bartholomew's Hospital and admitted under Mr. Skey's care, three months subsequent to the fall. After careful consideration, the swelling was laid freely open, the blood turned out, and the axillary artery tied above and below the aperture in its walls. Subsequently, the patient died; and, on *autopsy*, the humerus was found obliquely fractured in its upper third; the wound of the artery had been caused by a pointed piece of detached bone. There had been no dislocation.

The procedures for reducing dislocations of the shoulder-joint, especially for reducing those which have existed some considerable time, are quite liable to tear the walls of the axillary artery, and many examples of this accident have been placed on record. In some of them its occurrence has speedily been followed by death from shock and hemorrhage, as it was in the following case that was treated by Professor Gibson:—

A man, aged 50, presented himself with a luxation of the right arm, of two months' standing. Three weeks after the accident, it was said, four strong men had pulled on

[1] Élémens de Pathologie Chirurgicale, t. ii. pp. 368, 369.
[2] St. Bartholomew's Hospital, vol. ii. pp. 102, 103.
[3] Ibid., p. 102.

the arm without effect. Five weeks subsequently he was bled to the amount of twenty-four ounces, under Gibson's direction, and attempts at reduction were made, first with pulleys, then with five or six assistants; but, the patient becoming faint, these efforts were discontinued. Already a considerable axillary swelling was apparent, when, after two slight rotary movements, the head of the humerus suddenly slipped into its place. But the artery having been torn across, the swelling rapidly increased, the patient became blanched, and died some hours after the operation. On *autopsy*, the axillary artery was found torn directly across and separated from its connections, and there was a great quantity of coagulum in the axilla.[1]

Delpech's case of the mayor of Nîmes belongs to the same category: While he was reducing a luxation of the arm, in this case, the extension was made by six assistants; at the moment of reduction, the patient turned pale, lost consciousness, and did not recover it; he was dead. The cause of death was rupture of the axillary artery, according to M. Rigal, who was one of the six assistants, and mentioned the fact to Malgaigne.[2] The axillary region is capacious, its connective tissue very loose, and, therefore, when the axillary artery is opened subcutaneously, blood may be effused with great rapidity, and in great quantity; and this concealed hemorrhage may, if disregarded, and if the patient be kept in an upright posture, readily prove fatal.

Professor Lister has had a case where concealed hemorrhage of this sort occurred, and the accident proved quickly fatal:—

A man, aged 58, had dislocation of the shoulder, of seven or eight weeks' standing. Reduction was attempted by manipulation, and subsequently by pulleys, no undue force being exerted by either method. During the attempt a sharp crack was heard; a swelling appeared on the dorsal and posterior part of the scapula, which ultimately reached the size of an adult's head; it was due to a rupture of the axillary artery, with extravasation of blood into the surrounding structures. Without hesitation, Professor Lister cut down on the spot, and searched for the ruptured vessel. An aperture was found in the posterior part of the axillary artery, and a ligature was applied on each side of it. The patient rallied, but died about three hours afterwards. *Necroscopy* showed that the humerus had a small spiculum of bone attached to its shaft, which was the immediate cause of the rupture. The artery itself was very atheromatous.[3] A tumor of this description, as large as a man's head, would require for its production the loss to the circulation of an immense quantity of blood, enough to produce unaided in most cases anæmic exhaustion of a fatal nature.

Verduc[4] saw in a reduction of the humerus at the shoulder, the axillary artery torn, and, in consequence, an aneurism which speedily proved fatal. Petit[5] witnessed a similar accident. Platner[6] cites a case of rupture of the axillary artery and vein, in consequence of violent extension; which, doubtless, proved speedily fatal. Sir A. Cooper mentions a case of dislocation at the shoulder-joint, in which reduction was easily effected, but a false aneurism formed; and, the sac bursting, a fatal hemorrhage ensued.[7] The artery was found diseased and rigid. Mr. Rivington records the case of a man, aged 71, who died in consequence of hemorrhage from a traumatic aneurism of the axillary artery, that resulted from the reduction of a dislocated humerus.[8] The aneurism burst.

The sad result in each of these eight cases shows how great the danger of death from hemorrhage really is when the axillary artery chances to be torn

[1] Institutes and Practice of Surgery, vol. i. pp. 325–9.
[2] Traité des Fractures, etc., t. ii. p. 152.
[3] Medical Times and Gazette, February 1, 1873.
[4] Malgaigne, Traité des Fractures, etc., t. ii. p. 151.
[5] Ibid., p. 151.
[6] Ibid.
[7] On Dislocations and Fractures of the Joints, p. 371.
[8] Brit. Med. Journal, April 20, 1872.

in efforts for reducing dislocated shoulders; and, inasmuch as death may speedily follow the rupture from sub-tegumentary hemorrhage, as well as remotely from bursting of the aneurismal pouch, and external hemorrhage, the first indication in the treatment of these cases is plainly to restrain the flow of blood in the torn vessel by compressing digitally the subclavian artery against the first rib, as soon as the axillary swelling begins to appear, and by continuing the compression until the place of rupture can be exposed to view by incisions, and till the artery itself can be secured with catgut ligatures above and below the point at which it has given way.

This accident is also liable to be followed by gangrene. For example, Professor Gibson has reported the following case:—

A man, aged 35, with a dislocation of the left humerus of nine or ten weeks' standing, for which four attempts at reduction had been made, was the patient. Severe operative measures were employed, and, after an hour and three-quarters, the bone snapped into the glenoid cavity. At 8 o'clock next morning, an axillary swelling with characteristic pulsation was observed. The swelling increased, and at 3 P. M. next day, fifty-four hours after the reduction, the subclavian artery was tied, and the tumor ceased to pulsate. The limb, however, became gangrenous, and, on the sixth day after the operation, the man died.[1] The inner and middle coats of the artery were found torn across and separated for half an inch, and the external coat was dilated into an aneurismal sac, dating probably from the luxation itself, or from the previous attempts at reduction; during the last attempt the sac was torn open from behind, and an enormous effusion of blood entered the joint through the torn capsule. The rim of the glenoid cavity was fractured anteriorly.

In the British Medical Journal, May 18, 1872, is recorded the case of a man, aged 38, who dislocated his humerus and had it reduced. He was then admitted into the Northampton Infirmary. Gangrene of the arm ensued, and the man died. Fracture of the coracoid process, chipping of the head of the humerus, and rupture of the axillary artery, were found.

Flaubert has reported the following case which occurred in the practice of M. Leudet:—

A sailor, aged 57, was admitted to the hospital at Rouen, with a dislocation of the arm forward, of eleven days' standing. Extension was made by eight intelligent pupils, and, on the second attempt, the reduction was effected. But, just before relaxing the extension, the patient became pallid, his radial pulse ceased to beat, and an enormous swelling rose up under the great pectoral muscle. There was intense pain with pulsation in the tumor, and the whole arm became cold and livid. Gangrene little by little took possession of the limb. On the fourteenth day the aneurism burst in two places, and, an hour afterward, the patient died. The axillary artery was found torn completely across a little above the origin of the scapular. The pectoralis major and the coracoid portion of the biceps muscles were also extensively lacerated. The rim of the glenoid cavity, too, was broken.[2]

This accident is sometimes attended by death from exhaustion. For example, Mr. De Morgan, in a clinical lecture,[3] relates the case of a man, aged 54, who came under his care a fortnight after the reduction of a dislocation of the shoulder, under chloroform, with the heel in the axilla. Extravasation of blood into the axilla occurred, and increased. The man's strength failed, and he got rigors. Mr. De Morgan laid open the swelling, turned out the clots, etc.; but the man continued to sink. At the *necroscopy* it was impossible to detect the source of the bleeding. Anæmic exhaustion arising from loss of blood in the form of a concealed hemorrhage, however, is one of the most important causes of the deaths which result from this lesion.

[1] Am. Journ. of the Medical Sciences, pp. 136–141.
[2] Malgaigne, op. cit,, t. ii. p. 153.
[3] British Medical Journal, January 6, 1872.

The axillary artery may possibly be torn across in striving to reduce dislocations of the shoulder, in such manner that the bleeding may spontaneously cease, that the extravasated blood may undergo absorption, and that a cure may thus ensue, without operative interference. I believe that this fortunate occurrence is exemplified by the history of the following case:—

Professor H. B. Sands[1] was called to a lady, aged 86, seven or eight weeks after her right shoulder had been dislocated downward. Soon afterward it had been reduced. About ten days later, however, the dislocation was reproduced, and it remained in that state until Professor Sands's visit. The patient was etherized, and a very moderate effort was made at reduction. While arranging for a second attempt, five or six minutes subsequently, Dr. Sands thought he perceived a swelling in the axilla. He removed the sheet; it was very apparent that a bloodvessel had given way; there was a quite rapid increase of the swelling in the axillary region, and it was very soon as large as the head of a child at term. There was no pulsation in the radial, ulnar, or brachial artery. Nothing in the way of treatment was done, except to place the arm by the side and apply a bandage; but within half an hour the skin of the axilla had begun to show discoloration, and within a few hours the discoloration was very marked, and extended up to the shoulder. The patient was excessively prostrated by the accident, and at one time it seemed not improbable that she would die from syncope. Hypodermic injections of brandy were given, and brandy by the mouth as soon as it could be swallowed, but she remained in a very low condition for some time, especially at night. In the course of the next day after the accident, the extravasation gave signs of its presence quite distinctly, upon the side of the chest; and afterwards it could readily be seen on the side of the trunk as low as the pelvis. The discoloration behind covered nearly the entire scapular region. There was neither fluctuation nor murmur over the extravasation. There had been gradual improvement, and although pulsation had not returned in any of the arteries, the limb itself presented no unfavorable appearance. The patient made no special complaint, excepting a very uncomfortable tingling, at times along the distribution of the ulnar nerve. Professor Sands thought that no vessel except the axillary artery was ruptured, was surprised that the rupture should occur from the use of so little force, and was gratified at an unexpected recovery from so dangerous an accident.

The rapidity and copiousness with which the blood was effused in this case indicate that some large vessel was opened; the disappearance or cessation of the pulse in the radial, ulnar, and brachial arteries, together with the site of the tumefaction itself, shows that the axillary artery was the vessel ruptured. And, were the axillary artery completely torn across in this case, it was quite within the range of possibility for the ragged ends to become permanently closed by the contraction and retraction of the torn tunics of the artery, supplemented by the formation of a conical plug from coagulum in each end thereof, which would become organized. The natural hæmostasis in such cases is, no doubt, aided considerably by fastening the arm to the trunk with a broad roller.

The swellings appearing suddenly in the axilla during attempts to reduce old dislocations of the shoulder-joint, which the French surgeons formerly called *tumeurs aériennes*, and which usually ended in recovery without operation, were not unfrequently due to rupture of the axillary artery. The following example of *tumeur aérienne* occurred in the practice of Desault:—

A man, aged 60, came with a dislocation of a month and a half's standing. The reduction was scarcely achieved when a tumor was suddenly seen to rise up under the great pectoral muscle, and extend itself towards the armpit, occupying finally its whole extent. The pulse on the affected side became scarcely perceptible, and the man fell into a syncope. Desault himself at first feared that the axillary artery was ruptured. Methodical pressure was applied to the swelling by means of compresses and a bandage, which, at the same time, kept the arm fixed against the trunk. That night, acute pain

[1] Medical Record, January 10, 1880.

about the shoulder and the tumor came on; next day, high fever also appeared; on the third day they left. The swelling likewise abated, and, by the fifteenth day, had entirely disappeared. There still remained, however, a very extensive ecchymosis; but its resolution was complete on the twenty-seventh day.[1]

Considerable light is thrown upon the real nature of the lesion which existed in this case by what happened in a precisely similar case related by Pelletan,[2] the tradition of which had been preserved at the Hôtel-Dieu for almost twenty years. Whilst violent efforts to reduce a dislocation of the humerus, of four months' standing, were being made, a painful tearing occurred, and a large-sized tumor rose up. This tumor was declared to be emphysematous. It was opened by an incision; and the patient died of hemorrhage. Some of the eye-witnesses informed Pelletan that there was a rupture of the axillary artery with extravasation of blood. Had the incision not been made, the patient would probably have recovered.

Malgaigne relates another case which ended in recovery, without operation:—

A carman, aged 44, dislocated his humerus forward under the clavicle, and after suffering numerous unsuccessful attempts to reduce it, came to Malgaigne, who, on the sixty-eighth day, also attempted its reduction, and success seemed assured when he saw the subclavian hollow suddenly elevated by a tumefaction which almost visibly overran the axilla and part of the shoulder. Percussion gave a dull sound. Auscultation revealed nothing. The radial pulse continued to beat. The attempt at reduction, however, was at once abandoned, in order to avert the danger. The arm was immovably fixed against the side, and the tumor was covered with ice. Some hours later, the growth of the swelling seemed to be arrested. Soon afterwards, an enormous ecchymosis appeared. On the ninth day absorption had begun; and, on the twenty-second day, the tumor and the ecchymosis had vanished.[3]

Malgaigne thought that, inasmuch as the radial pulse was not affected, the axillary artery was not opened; but this circumstance only shows that the canal of the axillary artery was not obstructed. Recovery in such cases takes place without the obliteration of the canal. In one case, analogous to the above, Scarpa observed that the wounded edges of the artery had adhered, and that a mere line of cicatrization was discoverable when the artery was slit open. The coagulum, shut out in this manner from the canal of the vessel, formed a tumor which was attached to the outside of the artery.[4] Hodgson, also, remarks that "an aneurism arising from a punctured artery sometimes becomes filled with lamellated coagulum, which seals up the orifice through which the sac communicated with the artery, and the cure of the disease is accomplished without the canal of the artery being obliterated; the coagulum is absorbed, the sac contracts, and the orifice in the artery is permanently closed;"[5] and, in support of this view, he cites observations recorded by Saviard, Petit, Foubert, Scarpa, and Jones. It is obvious that when a rupture of the axillary artery is cured by Nature in either of these two ways the radial pulse may remain unaffected throughout.

*Symptoms and Diagnosis of Rupture of Axillary Artery.*—The phenomena which indicate that the axillary artery is ruptured, are those that arise from a rapid and copious effusion of blood into the loose connective tissue of the armpit, namely, a swelling appearing suddenly in some part of the axillary region, increasing quickly to a great size, so as to fully occupy that locality, and attended soon by discoloration of the integuments with infiltrated blood; the general signs of hemorrhage are often present, for instance, pallor of coun-

[1] Œuvres Chirurgicales, t. i. pp. 379, 380.
[2] Clinique Chirurgicale, t. ii. p. 95.
[3] Op. cit., t. ii. p. 150.
[4] Hodgson, Diseases of Arteries, pp. 489, 490.
[5] Ibid., pp. 488, 489.

tenance and lips, weak, rapid, or scarcely perceptible pulse, and great debility with marked faintness, or even complete syncope. The characteristic symptoms of aneurism, however, are very frequently absent, as the examples of this accident, which have already been presented, fairly show; for in many of them there was neither pulsation in the tumor, nor aneurismal thrill, nor aneurismal bruit, nor even circumscribed tumefaction. When the aperture in the artery is very small, or when the laceration does not at first extend through all the coats of the artery, the swelling may come on very slowly or very irregularly; and this circumstance, together with the absence of the symptoms which characterize aneurismal tumors, has led surgeons of deserved eminence into errors of diagnosis that have been attended with disastrous consequences. The following case, reported by Mr. Callender, illustrates in a useful manner the symptomatology and some of the difficulties which may attend the diagnosis of this accident:—

A gardener, aged 61, dislocated his left shoulder-joint by a fall. The luxation was reduced; but, from employing passive movements too soon, it recurred. At the beginning of the seventh week, Mr. Callender again reduced it, under chloroform, by circumduction, "with the exercise of very slight force." Immediately afterward, "a swelling, rapidly lifting itself and projecting the pectoral muscle," attracted his attention. It did not pulsate, and the radial artery beat naturally. He erroneously thought the main artery was not injured; "so the arm was confined by a bandage and the patient was removed to his bed." "The swelling having attained considerable size ceased to grow larger, and, as the man recovered from chloroform, there was no complaint of local pain." "The following morning, the patient's general condition was good." "The swelling beneath the pectoral muscle had become more diffused," "so that it extended around and behind the shoulder." "There was considerable ecchymosis," "as low as the buttock," "and the entire arm was œdematous." "No change occurred, save that the ecchymosis began to clear up," and the œdema of the arm was rapidly subsiding, until the fourth day. "Then, after straining at stool, he complained of pain about the shoulder, and it was evident that blood had been freshly effused." "The radial and ulnar arteries continued to beat normally." During the next thirty-eight days, the tumor "did not materially increase in size. But now it again enlarged itself." "As before, no pulsation existed in the swelling, nor was any bruit detected, carefully as it was naturally sought for." The confinement to bed and the local mischief were beginning to tell on the patient; it was decided to operate, about six weeks after the reduction of the luxation. An incision was made along the outer border of the pectoralis major, and was intersected by another, at its middle, extending inward through the whole thickness of the muscle, as high as the clavicle. When the great cavity thus opened was cleared of blood, some clots were seen projecting from behind the pectoralis minor. On removing them with a finger, a gush of arterial blood immediately followed. This bleeding was readily checked by compressing digitally the subclavian artery as it came over the first rib, and the distal portion in the lower part of the opened cavity. The pectoralis minor was then cut through, and it was seen that the bleeding came from a small, roundish aperture in the upper wall of the artery, and by pressing on this spot all hemorrhage was arrested. The vessel was next more completely exposed, and a ligature was passed around it on the distal side of the aperture, and then tied. A second ligature was placed on the vessel, about one inch above the first, and the artery itself was cut across midway between them. The walls of the vessel were considerably thickened. The principal veins and nerves were uninjured. For four days the patient did well. On the fifth day, the arm became gangrenous. On the afternoon of the seventh day, he died suddenly with symptoms of pulmonary embolism."[1]

Had a correct diagnosis been made at the outset of this case, and had a plan of treatment consisting of adequately compressing the subclavian artery upon the first rib, and likewise the tumor itself, and confining the arm to the chest

[1] St. Bartholomew's Hospital Reports, vol. ii. pp. 96–100.

by means of a broad roller, been judiciously carried out from the beginning, it is not improbable that the issue of the case would have been favorable.

The following example will serve to illustrate still further the symptomatology of this accident, and the errors of diagnosis which may attend it:—

A woman, aged 66, sustained a dislocation of the shoulder, which, at first unrecognized, was reduced at the end of six weeks by a "bone-setter," who made extension by the elbow and wrist, with the aid of four strong men. The arm remained engorged, and two or three months after the accident the patient entered the Hôtel-Dieu. Twelve days after admission, she received from another patient a blow on the elbow, which determined the appearance of a tumor in the axilla, of the size of an almond; and a pupil, who examined her at this time, found the radial pulse already absent. Six or eight days later, the swelling having increased, Dupuytren mistook it for an abscess; he thrust a bistoury into it, saw a jet of arterial blood escape, and, on making a better examination detected an obscure thrill in the tumor. He proposed to ligate the subclavian, a bold idea for the period (1810), but Pelletan would not allow it to be executed. Valsalva's plan of treatment was essayed; an eschar formed on the tumor, a hemorrhage completed the patient's exhaustion, and she died eight days after the puncture, and fourteen days after the appearance of the aneurismal tumor. On *autopsy*, the outer coat of the axillary artery was found dilated, through a space two inches long, to a diameter of one inch, where widest. This dilatation presented on its posterior, external aspect, an aperture which opened into the cavity of a very much larger swelling, equalling at least the size of a new-born infant's head, and having cellular tissue only for its wall. Above the dilatation, the artery was dry and hard; below, its canal was completely obliterated.[1]

It is probable that the employment of violent extension, in this case, was attended with rupture of the inner and middle coats of the axillary artery, and followed by dilatation of the outer coat into an aneurismal pouch; that the blow on the elbow made a small rent in this pouch, and led to an effusion of blood into the connective tissue of the armpit, which Dupuytren punctured because he thought it to be an abscess. Exploration of the tumor with the grooved needle, or even a critical examination of the tumor by ordinary means, would have prevented this sad mistake.

The sudden formation of a large swelling in the armpit, in consequence of a lesion of the axillary vessels resulting from a blow, or from a strain of the shoulder, or from violent extension of the arm, or from dislocation of the arm at the shoulder-joint, or from efforts to reduce this form of dislocation, is but seldom due to anything beside a rupture of the axillary artery. When such a swelling pulsates and presents the thrill and bruit of an aneurism, there is, of course, no difficulty whatever in determining its true character. But this is not often the case. Generally such swellings have neither pulsation, nor thrill, nor bruit. When, however, pulsation ceases in the radial, ulnar, and brachial arteries, simultaneously with the injury and the appearance of the axillary swelling, it is indicated with sufficient clearness that the continuity of the axillary artery as a canal or tube has been destroyed by the accident, or that the lumen of the vessel has been filled up by the lesion. When pulsation continues in the arteries of the forearm and arm, notwithstanding the tumefaction in the axilla, we must bring to our aid, in order to determine the nature of the tumefaction, the situation and extent of the subcutaneous ecchymosis, the gravity of the general signs of hemorrhage, the shape of, and degree of tension in, the axillary swelling itself, and a recollection of the fact that there are but three or four cases of uncomplicated rupture of the axillary vein on record, and that it is an accident of extremely rare occurrence. Moreover, when such a swelling is

[1] Pelletan, Clinique Chirurgicale, t. ii. p. 83; Dupuytren, Leçons Orales, 2me éd. t. iii. p. 12.

due to rupture of the axillary vein, it is likely to be much less tense and rounded than when it is due to rupture of the axillary artery. The continuance of the radial pulse when the axillary artery is torn open, denotes that its coats are perforated by a small aperture, that its canal remains open, and that possibly a cure may be effected by compressing the main artery on the cardiac side of the swelling, and by binding, at the same time, the arm to the trunk with a broad roller.

*Treatment.*—Sir Charles Bell relates that, at the infirmary of Newcastle, strong efforts to reduce a dislocation of the shoulder ruptured, at the same time, the muscles and the axillary artery, so that it was necessary to resort to immediate amputation.[1] The operation failed to save the patient. Syme, however, has amputated in three cases where the axillary artery had sustained a rupture, with success in each instance; and in cases where gangrene follows this accident, amputation in the upper third of the arm, or at the shoulder-joint, is almost our sole expedient.

Warren tied the subclavian artery successfully in the following instance:—

A man, aged 30, dislocated his shoulder whilst drunk. The reduction was immediately effected with the operator's boot in the axilla. A tumor formed in the armpit; forty-three days afterward it broke open, and two hemorrhages ensued. The subclavian artery was then tied in the third part of its course, and the life of the patient was saved.[2]

In the cases operated on by Mott and O'Reilly, which I have already presented, ligature of the subclavian artery was also followed by recovery. But in another case that was operated on by Nélaton, also presented above, ligature of the subclavian artery in the third part of its course was followed by bursting open of the aneurismal pouch, and by death from secondary hemorrhage. Furthermore, Panas has reported a case of axillary aneurism which supervened fifteen days after reducing a dislocation of the left shoulder. He tied the subclavian artery, external to the scaleni, but, three months afterwards, the patient died from suppuration of the aneurismal sac. The *autopsy* showed that the rupture had involved mainly the inner and middle tunics of the artery, and that it had occurred near the origin of the subscapular.[3] These cases of Nélaton and Panas clearly show that ruptures of the axillary artery, when treated by ligation of the subclavian in the third part of its course, are very liable to be followed by bursting open of the axillary swelling, and by death from secondary hemorrhage or from suppuration of the aneurismal cavity.

Blackman tied the axillary artery, in the first part of its course, without benefit, in the following case:—

A physician, aged 50, presented himself with a dislocation of the shoulder downward and inward, of sixteen weeks' duration, one unsuccessful attempt at reduction having been made ten weeks after the accident. Chloroform and ether (mixed) having been administered, the arm was adducted, rotated, abducted, and elevated; these manipulations having been continued about ten minutes, tumefaction appeared in the pectoral region, which in a few minutes attained considerable size, and it was then found that the radial and ulnar arteries had ceased to pulsate. Rupture of the axillary artery was diagnosed. The axillary itself was then tied in the upper part of its course, but the patient died on the twelfth day from secondary hemorrhage, occurring at the seat of ligation.[4] The untoward result in this case shows very clearly, I think, how badly adapted the operation of Anel is for affording relief in all similar cases.

[1] Malgaigne, Traité des Fractures, etc., t. ii. p. 151.
[2] American Journal of the Medical Sciences, 1846, vol. xi. p. 539.
[3] Nouveau Dictionnaire de Médecine et de Chirurgie pratiques, t. xiii. pp. 492, 493. Paris, 1870.
[4] Hamilton, Fractures and Dislocations, p. 657.

Sir James Paget, in a case of rupture of the axillary artery which I have already presented, laid the tumor freely open by a ⊥-shaped incision, scooped out the clots, found an oval-shaped aperture in the posterior wall of the artery, ligated the artery on each side of the aperture, and divided the vessel itself midway between the two ligatures. The loss of blood attending the operation was less than six ounces. The patient made a good recovery. By the same procedure, which is in substance the "old operation," Syme also treated with success two cases belonging to the same category. In such cases this method of operating should generally be preferred, because it is much less liable to be followed by secondary hemorrhage and suppuration of the sac than ligation of the subclavian artery in the third part of its course, or ligation of the axillary artery itself in the first part of its course. In performing the "old operation," the distal ligature should generally be applied before the proximal, because the flow of blood from the distal portion of the artery is apt to give the surgeon much more trouble than the hemorrhage from the proximal portion. The surgeon may, indeed, be strongly tempted to tie the subclavian artery in the third part of its course, on account of the comparative ease with which this operation can be performed, instead of cutting down upon the seat of the rupture, and tying the artery above and below it; but if he listen to this prompting of indolence, he may live to sorely regret his failure to employ the more difficult procedure.

Compression of the main artery on the cardiac side of the lesion has not, I believe, received that degree of attention in cases where the axillary artery is ruptured without external wound, and blood is being poured in great quantity into the loose connective tissue of the armpit, which its importance as a hæmostatic measure really demands. In the foregoing pages I have briefly presented thirty-four cases in which there was a rupture of the axillary artery. Twenty-six of them ended in death, and only eight in recovery; and in four of these successful cases, no treatment whatever was employed, excepting compression, with fixation of the arm to the side of the trunk by means of a bandage, and quietude; and in one instance the application of ice. When, therefore, the surgeon has the misfortune to witness the occurrence of this accident, he should immediately proceed to compress the subclavian artery against the first rib, for by so doing he will restrict the extravasation to a moderate amount, and may even effect a permanent cure. By this means he can at least prevent the concealed hemorrhage from going so far as to produce a fatal syncope in a short time, or anæmic exhaustion and death therefrom in the course of a few days. In most instances of extravasation from rupture of the axillary artery, as soon as the diagnosis becomes clear, the best course for the surgeon to pursue is, while continuing the pressure on the subclavian artery, to cut down upon and expose the axillary artery where it is lacerated, and to place a carbolized catgut ligature around it on each side of the laceration, finally dividing the vessel itself midway between the two ligatures. But when the surgeon is not called to the case until a great extravasation has already occurred, and the armpit is hugely distended with effused blood, the patient at the same time being cold, pallid, and almost pulseless from shock and hemorrhage, vigorous pressure should instantly be applied to the subclavian artery, and continued unceasingly, in order to prevent the further effusion of blood, until such time as the patient may have reacted sufficiently to allow the performance of the operation. Whenever a great extravasation of blood has occurred in consequence of this lesion, no operative procedure except the old one, or amputation at the shoulder, should be employed; and generally in such cases the cure should be attempted by compression supplemented by the "old operation." And, inasmuch as this operation is not always easy of performance, the surgeon will probably succeed best by thor-

oughly and faithfully compressing the main trunk on the cardiac side of the lesion, keeping the arm at the same time fastened to the chest by a broad roller, unless he possesses more than ordinary ability for operating on blood-vessels, and has the aid of at least one assistant, who is almost as competent as himself for such undertakings.

When, however, the laceration being but slight and restricted to the inner and middle coats of the axillary artery, the aneurismal tumor is developed but slowly, and has not yet attained a very considerable size—while it is also quite circumscribed, and has a genuine sac or a well-defined wall consisting of the external tunic of the artery, strengthened outwardly by laminæ of condensed connective tissue—it may be expedient to tie the subclavian artery in the third part of its course on the plan of Hunter, as was practised by Mott with success in a case which I have already presented. But in all cases where the tumefaction is very great, or is caused by extravasation of blood into the connective tissue of the armpit, the only plan of ligation admissible is the "old operation," whereby the clots are all taken out, and the artery itself is secured on each side of the laceration, and also divided midway between the two ligatures; for when this procedure is employed in such cases, the liability to death from secondary hemorrhage, or from suppuration of the sac, becomes very much less than it would be were Hunter's or Anel's operation performed. Furthermore, the surgeon should never make haste to use the knife so much as to ignore the diagnostic signs of this lesion; and in their absence he should place his main dependence on compression.

Before quitting this subject it will be useful for me to point out the principal methods by which compression may be successfully applied to the subclavian artery for the cure of axillary aneurism; and I cannot do this more clearly and tersely than by presenting a few examples in point:—

A man, aged 71, under the care of Mr. Erichsen, in whom the aneurismal tumor had been noticed only one month, had compression applied for twenty-five hours —digital compression for eleven hours and mechanical for fourteen. The treatment extended from June 23 to August 12, and resulted in cure.[1]

Mr. Cooper Forster also records a case. Pressure (digital and with a key) was applied to the subclavian, at intervals, for three days, with some benefit; and then, under chloroform, with a key above the clavicle, for five and a half hours, with complete success. It was, however, continued three hours longer.[2]

M. Verneuil[3] had under his care a man suffering from an aneurism in the left axilla, having a diameter of about three and a half inches. First the arm was carried backward, pronated, and adducted, and fastened in this position to the thorax, but the patient could not bear this position of the limb any considerable length of time. Then digital compression of the subclavian artery (above the clavicle) was continued for twenty-four hours, but had to be abandoned, as the assistants became fatigued. A thick plaster of gypsum was now laid in the supra-clavicular region, and digital compression was made through it until the plaster had become hardened. From the model of the part thus obtained, a leaden cast, weighing six and a half pounds, was made, and it was used for effecting compression of the subclavian, its potency being increased by means of a handle. The patient ultimately attached to the handle three bands, which were fastened to the bed in various directions, and kept the mass of lead in place. This plan succeeded perfectly, when the weight was increased to about eleven pounds. By this means the subclavian artery was compressed during six or seven hours daily for about ten weeks, at the end of which time the size of the swelling had become reduced by nearly one-half, and the pulsations had almost ceased. The patient

[1] Lancet, November 15, 1873.
[2] Guy's Hospital Reports, 3d S. vol. xviii. p. 61.
[3] Gazette Hebdomadaire, No. 12, 1873.

was now dismissed from the hospital, but continued to apply the compression at home during several hours daily for ten months. Several years later he reported that the cure was complete; the place of the aneurism was occupied by a hard mass of the size of a nut, which did not impair the usefulness of the arm.

Generally, compression, applied in some of the ways mentioned above, should be faithfully tried before resorting to operative procedures with the knife, for the cure of traumatic aneurism of the axilla.

In cases where the "old operation" is practised, a drainage tube, deeply inserted, should be left in the wound. In such cases, also, antiseptic dressings are of great value, and, therefore, should be exclusively employed.

When the torn artery has been ligated above and below the rent in its tunics, by this method, should secondary hemorrhage ensue, the wound of operation must be promptly reopened, the bleeding point sought for and found, and tied anew with carbolized catgut.

Amputation near the shoulder, performed without delay, is the only expedient that can save the patient in cases where gangrene attacks the limb in consequence of an occlusion of the axillary artery resulting from rupture of its inner and middle coats, as happened in the cases reported by Professor A. Bérard, and Inspector-General Smart, R. N., which I have already presented. In such cases, the gangrene usually appears first in the fingers.

When the other arteries of similar magnitude that belong to the extremities, both lower and upper, are ruptured without external wound, the treatment should be conducted on the same general plan, for the underlying principles remain unchanged.

Lacerations of the Main Arteries of the Extremities Caused by Fracture of the Long Bones.—This accident has often been met with in the leg, and numerous examples of it have been reported. Dupuytren says that, from 1806 to 1825, he witnessed as many as seven cases of diffuse aneurism caused by fractures of the leg. He also says: "It may be that practitioners have overlooked this serious complication of fractures and gunshot wounds, because they have regarded it as beyond the ordinary resources of art to cure;" and he adds that, "in such cases, the universal recommendation has been to amputate." But this mode of treatment has been attended with a great fatality. For example, Pelletan amputated the thigh in three cases belonging to this category, and lost two of his patients by death.

J. L. Petit, in a fracture of the leg without external wound, saw the artery which passes between the two bones (doubtless the anterior tibial) laid open by the sharp edge of the broken tibia. The whole leg and foot became greatly swelled and ecchymosed; the part also became cold as well as discolored, and appeared gangrenous. He laid open the leg by an incision about six inches in length, extending above and below the fracture, and, discovering the open vessel, arrested the hemorrhage without displacing the bones. The case was then treated as an ordinary compound fracture, with success. This innovation was a great improvement. Boyer also recommended this plan of treatment, which consists essentially in cutting down upon the lacerated artery and tying its bleeding extremities.

Dupuytren, in 1809, tied the femoral artery at the middle of the thigh, in a woman, aged 62, for the cure of a diffuse aneurism resulting from a simple fracture involving both bones of the leg, at the junction of the middle and inferior thirds. The fracture was oblique; there was also great swelling and tension of the surrounding soft parts. On attempting the reduction, Dupuytren felt in the calf of the leg strong pulsation, distinct to the eye as well as to the touch, and synchronous with the heart's action; disappearing, too, on compressing the femoral artery, and returning on the withdrawal of the com-

pression. The vessel lacerated was, in all probability, the posterior tibial artery. The application of the ligature immediately suppressed all further pulsation in the tumor. On the sixth day the bulk of the tumor was already lessened by one-third. The woman perfectly recovered. Delpech, in 1815, acting on this precedent, ligated the femoral artery toward the upper part of the thigh, in the case of a postillion, aged 30, who had sustained a simple comminuted fracture of both bones of the leg near the centre, from the passage over it of the wheel of a loaded cart. The leg was discolored, and excessively distended from tumefaction. The tumefaction itself pulsated distinctly, especially at the calf; the pulsations were synchronous with those of the heart, and were controlled by pressure on the femoral artery. The patient made a good recovery. Dupuytren, in 1818, in a case of compound fracture, employed the same method that had been successfully employed in these two cases of simple fracture of the leg. An officer was shot through the upper part of his right leg by a pistol-ball. It passed from before backward and inward, traversing the interosseous space, and injuring both bones. Severe hemorrhage from both apertures immediately ensued; it was arrested by compresses. The leg swelled and became acutely painful; and afterward alarmingly benumbed. There was no external hemorrhage until the thirteenth day; but, meanwhile, blood was extravasated so as to form a diffuse aneurism which increased day by day in size, and exhibited pulsations which were synchronous with those of the heart, and immediately ceased on compressing the femoral artery. The hemorrhage which occurred on the thirteenth day was repeated at intervals, and greatly reduced the patient. At this time Dupuytren was called in, and found that the foot and leg were tumid, purple, cold, and benumbed; that there was a tense tumor at the upper part of the leg, which expanded and contracted with each beat of the heart; that this swelling was surmounted by two apertures, one in front, the other behind, made by the entrance and exit of the ball; and that these apertures had, for the last few hours, been closed by plugs of coagulated blood, which each pulsation threatened to dislodge. Fortified by his previous success, he tied the femoral artery at the middle of the thigh. Before tightening the ligature, he ascertained that pressure on the exposed artery arrested pulsation in the tumor. In three months the patient perfectly recovered.[1]

Verneuil, in 1859, reported a case of diffuse aneurism from simple fracture of the leg, in which a new and much simpler plan of treatment was equally successful. The patient, being on horseback, struck his leg against a carriage-shaft, and broke it, but the fracture was masked during fifteen days by the swelling. The swollen region, however, was the seat of pulsations, synchronous with those of the femoral artery, and disappearing on compressing that vessel; the presence of a murmur or bruit was always doubtful. The arteria dorsalis pedis remained unaffected. Compression (intermittent) of the femoral artery upon the pubis was made by the patient himself; afterward, bags of shot were applied over the course of the femoral artery, and the cure became complete. Thus Verneuil avoided both amputation and ligation with perfect success. Azam has published a case of diffuse aneurism, with pulsation and murmur, that was caused by simple fracture of the leg at its inferior part, in which a cure was obtained by compressing the femoral artery at the pubis. The patient himself, by means of a watch-glass, compressed the artery from six to eight hours daily. Two months after the accident, the callus was solid and the cure complete.[2] Valette (de Lyon) has reported two analogous cases in which a cure was also obtained by compressing the femoral

[1] Leçons Orales, t. ii. pp. 521 *et seq.* Paris, 1839.
[2] Nouveau Dictionnaire de Médecine et de Chirurgie pratiques, t. xix. p. 550. Paris, 1874.

artery. In one of them, the fracture was complicated with an external wound of the leg, and with severe primary hemorrhage, which, however, was suppressed by pressure combined with the local use of the perchloride of iron. On the twentieth day the hemorrhage reappeared; the same means were again employed, but they failed to control it. Finally, Valette stopped the bleeding by digital compression of the femoral artery; and compression thus applied was continued during about ten days, by four journeymen locksmiths, comrades of the patient, who relieved each other every four hours. The wounded man completely recovered. In the other instance, compression of the femoral artery also succeeded, but the success was perhaps less striking, because the hemorrhage was less severe; nevertheless, the result was highly encouraging for the future employment of compression.[1]

*Symptoms of Arterial Laceration due to Fracture.*—In cases of simple fracture, the occurrence of this accident is denoted by the following signs: tumefaction tense in character, discolored by subcutaneous ecchymosis, increasing rapidly, and pulsating synchronously with the heart; the pulsations themselves ceasing on compressing the main artery on the cardiac side of the swelling, and returning on withdrawing the compression; and the tenseness of the swelling growing markedly less under compression of the main artery, to return again when the compression is discontinued. The peculiar thrills and murmurs which are found in spontaneous aneurisms may also be present in diffuse aneurisms from fracture. But the thrill is often, and the murmur sometimes, absent in such cases. For instance, in Verneuil's case, related above, the presence of a murmur was always dubious. When the arterial wound is very small or very oblique, neither distinct pulsations, nor aneurismal thrills, nor aneurismal bruits are to be found, but only an impulsion, synchronous with the contraction of the heart, is imparted to or discernible by the hand. In an example presented by Dupuytren, a sort of tremulous movement, increasing and diminishing alternately, was perceptible in the swelling, but no distinct pulsation. This tremulous movement, however, ceased when the popliteal artery was compressed; and, at the same time, the swelling was observed to become less tense, and to diminish a little in volume. The tremulous movement, and the tension, and the volume of the swelling, too, were restored when the pressure was removed from the artery. The diagnosis was, therefore, not doubtful. Moreover, in certain patients an aneurismal bruit has been recognized in the swelling, when pulsation, or impulsion, or tremulous movements have been wholly wanting in it. The symptoms of diffuse aneurism may not appear until several days after the fracture, because the artery remains unopened until that time. In one of Pelletan's cases, they did not appear until the seventy-fifth day. In such cases the artery is, for the most part, penetrated by ulceration from pressure exerted by the fragments.

When the fracture is compound and the hemorrhage is external, the blood is bright red, but it rarely issues in jets. As syncope approaches, the bleeding can generally be stopped by local applications, but after some days it returns as strongly as ever; it may do so again and again, and, if they be not properly treated, these successive hemorrhages must end by carrying off the patient. One of Valette's cases, related above, illustrates this point; so also does one of Dupuytren's examples.

Fr. Poncet[2] presents in a tabular form twenty-one cases of diffuse aneurism resulting from fracture of the leg, that occurred in the practice of Ribes, Desault, Dupuytren, Delpech, Mirault, Lisfranc, Guthrie, Travers, and others,

[1] Ibid., t. xix. p. 585. Paris, 1874.

[2] Nouveau Dictionnaire de Médecine et de Chirurgie pratiques, t. xv. p. 497. Paris, 1872.

in which either ligation or compression was resorted to. No mention, however, is made therein of those instances of this accident, although they are quite numerous, which have been treated by amputation of the thigh, or have been allowed to run their course without surgical interference, and which have terminated fatally by hemorrhage or by gangrene. The following is a brief summary of the tabulated cases:[1]—

| | Cures. | Deaths. |
|---|---|---|
| Ligature of the femoral artery has furnished | 5 | 1 |
| Ligature of the tibial above the tumor | 3 | 2 |
| Ligature of the peroneal | 2 | — |
| Compression applied in the wound | — | 2 |
| Compression applied to the main artery above | 3 | — |
| Add the cases of Verneuil and Valette | 3 | — |
| | 16 | 5 |

To these, Azam's case, related above, in which a cure was obtained by compressing the femoral artery at the pubis, is to be added, which gives in all seven examples of this formidable lesion that have been cured by indirect compression, without any accident, and without any failure. Ligature of the femoral artery at or above the middle of the thigh has furnished five recoveries, and one death. The most dangerous plans of treatment are, beyond doubt, compression applied in the wound, and ligature of the injured artery immediately above the tumor; and, therefore, these should generally be considered as inapplicable to, and not permissible for, this lesion.

*Appreciation of Methods.*—There are four distinct surgical procedures which may at times be required in treating the lacerations of arteries which are caused by fractures of the leg. (1) Indirect compression, that is, compression of the parent vessel, or arterial trunk, on the cardiac side of the laceration, at some considerable distance from it. (2) Ligature of the lacerated artery itself, on each side of the laceration. (3) Ligature of the superficial femoral artery, at or above the middle of the thigh. (4) Amputation.

(1) *Compression* of the femoral artery at the pubis, from its innocuousness, and the remarkable success which has attended its use, is far preferable to every other plan of treatment; and the surgeon should always make faithful trial of it, when practicable, before proceeding to operate with the knife. It is always advisable to make digital compression in such cases, if possible; but this plan of treatment requires the co-operation of at least several intelligent assistants; these are not always at hand, and in the country especially the surgeon may ofttimes be unable to find them. He should then, if he can, resort to the use of instruments for compressing the femoral artery, such as I have already described on pages 71 *et seq.* But, after all, there will be cases in which, either from want of the means to make compression, or from failure of the compression itself, recourse must be had to other procedures.

(2) The "*old operation*," that is, the ligation of the torn artery itself in the wound, above and below the rent in its tunic, although J. L. Petit performed it with success, is not admissible in cases of simple fracture, because it would convert them into compound fractures. There is no pretext under which a surgeon can justify himself in voluntarily converting a subcutaneous into an open fracture. But in cases where the fracture is already compound, and the hemorrhage is external, when compression of the femoral artery at the pubis is impracticable or ineffectual, it is often, perhaps generally, advisable to lay open the swelling, by enlarging the original wound, if necessary, in order to

[1] There are also a good many instances of this accident on record in which the "old operation" was performed, or recovery spontaneously occurred, that are not mentioned or embraced in Poncet's table.

find the lacerated artery and secure it with ligatures of carbolized catgut applied on each side of the aperture in its walls. The external wound should then be closed and treated antiseptically.

(3) *Ligation* of the superficial femoral artery, at or above the middle of the thigh, as originally recommended and practised by Dupuytren, is the operation which must be performed in cases of diffuse aneurism resulting from fractures of the leg that are simple or unattended with external wounds, whenever compression of the femoral artery is impracticable or proves ineffectual.

(4) *Amputation* at the knee should be performed, without delay, as soon as gangrene appears in the toes or foot belonging to a limb where this accident has occurred; and there is but one circumstance besides gangrene which makes this operation admissible for the lesion in question, and that circumstance is the failure of all other plans of treatment.

The surgeon should, generally, when this accident has occurred, be in no great hurry to operate with the knife, unless there is external hemorrhage not amenable to compression, or unless gangrene makes its appearance; and then he cannot perform the operation of ligation on the one hand, or amputation on the other, too speedily.

Concerning the application of compression to the femoral artery for this lesion, the surgeon should never, in an excess of zeal or anxiety, ignore the fact that it need not suspend the circulation entirely, need not even act continuously, in order to effect a cure. In several of the cases presented above, where the success was most striking, the compression was intermittingly applied, and in two instances it was made by the patients themselves. Thus the surgeon may, without risk, substitute for the intolerable torture of the old modes of compression, a treatment which, in ordinary cases, is harmless, and which, in a few, is absolutely painless.

But the occurrence of diffuse traumatic aneurism in consequence of fracture is not restricted to the leg, although it is met with in that region much oftener than elsewhere. Fractures of the thigh, likewise, are not unfrequently complicated by lacerations of large arteries, and by the appearance of sanguineous tumefactions communicating with the canals of the torn vessels, which, in default of a more appropriate name, are called diffuse traumatic aneurisms. Gürlt[1] presents a long statistical table, containing twenty-five examples of this accident that occurred in the thigh, leg, and arm; *four* of them were observed in the thigh, *twenty* in the leg, and *one* in the arm. The four thigh cases were reported by Bransby Cooper, by Lyon of Glasgow, by Trugen of Posen, and by Guthrie. Three of these patients died and only one recovered. The excessive mortality sufficiently attests the gravity of the lesion. The following case occurred at the Middlesex Hospital, under the care of Mr. Moore:—

In a man, aged 35, having simple fracture of the femur, there was an extensive swelling of the thigh, together with an arterial bruit in some vessel—not the femoral artery—which could be felt below the seat of injury.[2] The symptoms of an arterial wound in this case, viz., the bruit and swelling, disappeared under the influence of the absolute rest of limb and general quietude of body which the fracture necessitated, that is, without any special treatment, and the fracture itself united in three months.

It is probable that in the examples of this accident met with in the thigh, the branches of the femoral artery are the seat of the lesion much oftener than the parent vessel.

[1] Handbuch der Lehre von den Knochenbrüchen, Bd. i. S. 526–537.
[2] Holmes's System of Surgery, second ed., vol. iii. pp. 519, 520.

The arm case contained in Gürlt's statistical table was reported by Perussault, and the patient recovered. There was crushing (*zerschmetterung*) of the external condyle of the right humerus, of the olecranon, of the radius, and of the ulna. The following arm case was under Mr. Moore's care at the Middlesex Hospital, and is of special value in this connection, because it illustrates the subject much better than many words of abstract description:—

A woman, aged 42, injured her right arm by falling down stairs at night, and presented herself next day. The whole hand and forearm, and part of the upper arm, were tensely swollen and covered with bullæ of various, but principally of small size. Serum mixed with blood filled the bullæ. Fracture of the olecranon was easily made out, but no other osseous lesion could be detected. On the following day the swelling was larger, and the vesications more extensive. There was an aneurismal pulsation in front of the elbow, strong and expanding, but deeply seated. The impulse extended half-way up the inner side of the arm, and more than half-way down the whole palmar surface of the forearm. A distinct bruit was heard with the stethoscope in front of the elbow. The two arteries at the wrist beat so forward and so forcibly, and appeared so much larger than those of the other side, as to give the idea that they had been raised up by extravasated blood, and that the pulsation was communicated to the distended sheaths of the vessels. The skin on the hand was dusky from congestion; and when the color was expelled by pressure, it returned very slowly, showing the embarrassed condition of the circulation. The limb was everywhere warm, however, and there was no sign of impending gangrene. At the consultations various opinions were expressed as to the appropriate treatment; but it was agreed that some large artery, possibly the brachial, was wounded. It was ultimately decided to watch the case. In the evening, the swelling was found not to have increased, and the hand was certainly less tense. A rounded swelling was found near the armpit, in the neighborhood of the brachial artery, which appeared to be the end of the clot of extravasated blood. On the following day (the third from the accident) pulsation had ceased in all other parts, and was perceptible only in front of the elbow, over a space about as large as a half-crown, and not strong. Next day the aneurismal pulsation disappeared, and the swelling afterward gradually subsided. When the subsidence was sufficient, fracture of the lower end of the humerus was detected. The case did well.[1] This case shows that lacerations of healthy arteries, when uncomplicated with external wounds, sometimes show a remarkably strong tendency to recovery.

Mr. De Morgan, in a clinical lecture at the Middlesex Hospital, also says: "We have had, within the last few years, two or three cases of simple fracture where there was a large and rapid effusion of blood beneath the skin, and marked aneurismal pulsation; in which, however, arrest of the hemorrhage ensued spontaneously, and complete absorption took place, although it was clear that a large artery had been torn through."[2]

Diffuse traumatic aneurisms, resulting from fractures, when they occur in the thigh or arm, should be treated on exactly the same principles as when they occur in the leg, a thorough discussion of which accidents has just been presented. I must, however, add that examples of this accident occurring in the leg, too, sometimes recover without any special treatment of the arterial lesion. Such a case was under the care of Mr. Mitchell Henry, at the Middlesex Hospital. The posterior tibial artery was wounded, in a boy who had simple fracture of the leg. The diagnosis rested on the absence of pulsation in that artery and the presence of bruit in the swelling, together with a peculiar restlessness of the limb. The fracture healed slowly (in about two months), and these symptoms gradually subsided, but the pulse did not return in the affected artery.[3] In such cases it is sometimes said that the arterial wound heals spontaneously; it must not be forgotten, however, that but few

[1] Ibid., pp. 519, 520. [2] British Medical Journal, January 6, 1872.
[3] Holmes, System of Surgery, 2d ed. vol. iii. pp. 519, 520.

things which the surgeon may do can promote the closure of the torn artery and the absorption of the extravasated blood, more effectually than the fixed position, absolute quietude, and equable support of the injured part, with general quietude of the whole body, which the fracture and its dressings enforce. Compression, digital or instrumental, of the main artery, should always be thoroughly tried in the thigh and arm, as well as in the cases of this accident occurring in the leg, before resorting to the "old operation," or to ligation of the main artery on Hunter's plan.

There is good ground for hope that almost all arteries of the extremities, both lower and upper, when wounded in cases of simple fracture, will heal when the fixed position and quietude, just mentioned, are supplemented by adequate compression of the parent vessel. The appearance of gangrene in such cases necessitates the immediate performance of amputation.

But traumatic aneurisms resulting from fractures are not confined to the regions of the leg, thigh, and arm; they are also found in any part of the body where an artery lies sufficiently near the bone to be pierced or torn by its broken fragments. Mr. Busk and Mr. Curling have each placed on record a case in which a traumatic aneurism formed upon the ophthalmic artery in consequence of fracture of the base of the skull. In both cases the carotid artery was tied, and in both with complete success.[1]

## Gunshot Wounds of Arteries.

The large arteries of the extremities are, to a considerable extent, protected from gunshot perforations, by the strength of the fibrous sheaths which invest them, by the toughness and extensibility of their own tunics, and by the readiness with which they can slip aside from the track of a gunshot missile, owing to the fact that they are elastic tubes, and that their contents are liquid. By these means, doubtless, the large bloodvessels often escape lacerations from bullets; and in this way we can account for the fact that such arteries as the femoral, the carotid, and the brachial are found to be practically uninjured, although lying exactly in what appears to be the track of the missile. The late civil war furnished numerous examples. "A number of drawings at the Army Medical Museum, exhibiting the course of balls directly in the track of the great bloodvessels of the neck or of the limbs, illustrate the fact, so well known to military surgeons, of the great resiliency of the large arteries."[2] The surgical historian of the British Army in the Crimean War justly observes:—

> "The amount of this resiliency of the large arteries of a limb is much greater than is usually supposed. Thus, in a soldier of the 56th Regiment, a fragment of shell passed through the ham, between the artery and the bone, without injuring either, although it was much too large to have done so without displacing the vessel. The man afterwards died of diarrhœa. In the 9th Regiment a similar case occurred, but in it a portion of the bone was scooped out by the missile, and the man recovered. In the 47th Regiment, a large piece of shell passed through the upper third of the thigh, between the artery and the bone, but injured neither, and recovery took place."[3]

Notwithstanding this wonderful resiliency of the arteries of the neck and extremities, which oftentimes enables them to escape all serious injury even when they appear to lie exactly in the track of wounds made by gunshot missiles, it not unfrequently happens that they sustain solutions of continuity

[1] Medico-Chirurgical Transactions, vols. xxii, xxxvii.
[2] Circular No. 6, S. G. O., p. 39.
[3] Surgical History of the Crimean War, vol. ii. p. 340.

from the impact of such missiles. Experience has shown that these arteries may be wounded in such a way as to have their calibres directly opened by musket, rifle, carbine, and pistol-balls, by case-shot, and by fragments of shells. It seems, however, to be necessary for the accomplishment of such a result, that the missile should be moving with great velocity at the moment when it strikes the artery. Hence it happens that bullets are much less likely to penetrate the arteries after they have passed through the compact structure of the long bones of the extremities, than they are before making such a passage through osseous tissue. If the velocity of the missile has been considerably lessened ere it impinges against the artery, it may only bruise its tunics;[1] but, in so doing, it may cause as much damage to the patient as it would have done by opening its calibre.

The solutions of continuity or breaches, produced in the walls of bloodvessels by gunshot missiles, are essentially contused and lacerated in their nature, and usually present some of the features which belong to each of those classes of injury. They can, therefore, be most conveniently considered in this place, that is, immediately after the contused and lacerated wounds of arteries have been discussed.

The breaches in the walls of bloodvessels which gunshot projectiles occasion may be separated into two important groups:—

1st. Partial or incomplete division of the vessel, considered as a tube for the transmission of blood.

2d. Complete division of the same.

We find, on studying attentively the details of this subject, that each of these groups presents peculiarities in respect to phenomena and consequences, of so much importance in both a scientific and practical point of view as to demand for each a separate consideration.

Examples of gunshot injury in which the wound of an artery constitutes the sole or even the principal primary lesion are not of frequent occurrence in surgical practice, and are not often met with by surgeons even on battle-fields, although arterial wounds very often present themselves as complications, it is said, of gunshot fractures and other important injuries. On this point the late Dr. Otis, the distinguished historiographer of our civil war, remarks:—

"The number of cases reported under this head is extremely small. In the campaign of the Army of the Potomac, from the Rapidan to the James, in May, June, and July, 1864, of a total of 36,508 gunshot wounds, only twenty-seven belonged to this category. The cases of compound fracture complicated with injuries of the large vessels, the cases in which limbs are carried away by solid shot or shell, and the cases in which all the tissues of the limb are disorganized by contusion from a large projectile, and the vitality of the arteries is destroyed, are all returned under other heads. Those only are included in which the canal of a large vessel is primarily opened, and in which this is the principal accident. Such cases are to be sought for among the dead on the battle-field, rather than in the field hospitals."[2]

Again, in almost all the cases where an artery of considerable magnitude has been opened by a gunshot missile, which are brought to the surgeon for treatment on the field of battle, the injured vessel is found to be situated in the extremities, in the neck, or in the head, but most frequently in the extremities. Gunshot wounds of the great arteries of the abdomen and the thorax fail to come under the notice of military surgeons, not because these vessels escape all injury, but because, whenever they are opened, death usually very speedily ensues. I am fully convinced from personal observation, that these vessels are frequently wounded in battle; that such injury is, for the

[1] See Contused Wounds of Arteries.

[2] Circular No. 6, S. G. O., pp. 38, 39.

most part, very quickly followed by death from hemorrhage; and that this form of gunshot lesion should be ranked as one of the principal causes of sudden death in warfare. The subjects of this form of gunshot injury almost always perish from hemorrhage before they can be taken up from the field, and hence they are generally reported on the company-rolls as killed.

Partial or Incomplete Division of Arteries by Gunshot Missiles.—This lesion presents itself in two principal forms. In one of them a side of the arterial tube has been carried away; in the other, the vessel has been perforated through and through by the missile. The former occurs much oftener than the latter. The former is met with in vessels presenting much variety in respect to size; the latter only in large ones. But the consequences of the arterial wound are quite similar in both instances.

The following abstract, and the woodcut which accompanies it (Fig. 423), afford a most excellent example and illustration of the partial division of a large artery by a cylindro-conoidal bullet:—

A soldier, aged 19,[1] was accidentally wounded, January 11, 1866. The missile, a conoidal musket-ball, entered his right side, just below the cartilages of the false ribs, passed upward, and fractured the eighth rib; it then emerged from the chest, and, entering the axilla, traversed the arm, and passed out at the top of the shoulder, without

Fig. 423.

Gunshot wound of the right axillary artery; pieces of cloth, driven in by the ball, moderated the bleeding. (Spec. 2674, Sect. I., A. M. M.)

injuring the humerus. He was taken to the post-hospital, in a state of syncope, unable to speak and almost pulseless. His extremities were cold, and he was said to have lost a bucketful of blood. Powerful stimulants were immediately administered. The hemorrhage did not return until the 20th, when he lost about fifteen ounces. It was stopped by compression. It again recurred on the 21st, and he lost about twenty ounces. On the 22d, although the prostration from loss of blood was extreme, it was deemed expedient to tie the axillary artery, which was accordingly done with a single ligature; but he survived the operation only a few minutes. During the operation several fragments of cloth were extracted, and also two pieces of the axillary artery. On the extraction of the cloth, hemorrhage, *per saltum*, commenced, but it was easily controlled by compressing the subclavian above the clavicle, with a door-key. *Necroscopy*—A large semicircular piece, embracing about half the calibre of the vessel, was cleanly cut out by the ball from the side of the axillary artery, about one inch below its origin; brachial plexus uninjured. The fragments of cloth and flesh which were extracted during the operation had doubtless been driven into the artery, and their dislodgment by accident or by suppuration brought on the secondary bleeding. Such a wound of the axillary artery usually causes death from primary hemorrhage in about five minutes. The accompanying woodcut (Fig. 423) represents the specimen, which is preserved in the Army Medical Museum.

The wound was inflicted, whilst the man was lying in his tent, by a comrade who was handling a loaded musket. The missile was therefore moving with great velocity, and it cut cleanly out a large semicircular piece from the side of the axillary artery, embracing about one-half its calibre. Generally, when large arteries are laid open by gunshot missiles, the wounds are inflicted at short range by small-arm projectiles, the missiles moving with great velocity at the moment of impact; especially when such arteries as the

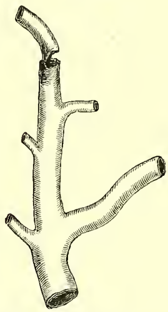
[1] Med. and Surg. History of the War of the Rebellion, First Surg. Vol., p. 553.

femoral, the carotids, the axillary, and the brachial, are involved. But wounds inflicted at long range by the same class of projectiles, may be attended with contusion of these arteries; or, from their resiliency, they may escape all appreciable injury.

An important fact connected with this case, wherein the main artery of the upper extremity was cut half-way across by a cylindro-conoidal ball, only one inch below where it is called subclavian, is that the bits of cloth carried into the wound by the ball, and the occurrence of syncope, stopped the primary hemorrhage. Another important fact is, that the bleeding was restrained for nine days, that is, until the bits of cloth, pieces of flesh, and occluding clots had become loosened and detached by suppuration.

The following abstract and woodcut (Fig. 424) present us with another instance and illustration of the incomplete division of a large artery by a cylindro-conoidal missile:—

Fig. 424.



Shot-wound of the external carotid, near the origin of the internal maxillary artery. (Spec. 2222, Sect. I., A. M. M.)

A corporal, aged 22,[1] was wounded May 3, 1863, by a conoidal musket-ball, which entered the nose and escaped near the right ear, having shattered the right superior maxilla in its course. Slight hemorrhage began on the 9th, but it yielded to compression. It recurred, however, several times with great profuseness; the patient became frantic with alarm, and prevented all attempts at compression, etc.; and died, rather suddenly, from hemorrhage, on the 11th—eight days after the casualty. The specimen is represented in the accompanying woodcut (Fig. 424), which shows the terminal portion of the common carotid, the first portion of the internal carotid, and the external carotid from its origin up to and beyond the site of the gunshot lesion of its walls.

In this case the primary hemorrhage, which doubtless was severe, ceased on the approach of syncope; for the bruised and lacerated tissues surrounding the track of the ball afforded a good lodgment for a coagulum to plug the wound, and thus stop the outflow of blood. The hemorrhage was restrained until the sixth day, when the bruised and lacerated tissues, or the slough, surrounding the hole made by the ball, began to get loose, preparatory to their discharge by ulceration.

The following abstract and woodcut (Fig. 425) also illustrate in a useful manner the partial division of a large artery by a gunshot projectile:—

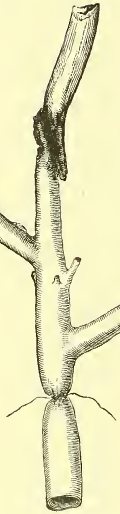
A soldier,[2] aged 25, on July 3, 1863, received a gunshot wound of the neck and face. On the 9th, secondary hemorrhage from the external carotid artery, to the extent of twelve ounces, occurred. On the 10th, the common carotid was ligated, three-quarters of an inch below the bifurcation. The hemorrhage did not return; but, on the 13th, the patient died. The specimen is represented in the annexed woodcut, which shows well the lesion of the external carotid, the ligature in position on the terminal portion of the common carotid, etc. (Fig. 425.)

As in the last case, so in this, the hemorrhage was restrained by the coagulum that plugged the wound until the sixth day, when the slough began to separate. But the secondary bleeding which then occurred was arrested by tying the common carotid artery, and did not return. The patient, however, died three days after the operation, probably from anæmic exhaustion caused

[1] Med. and Surg. History of the War of the Rebellion, First Surg. Vol., p. 396; also, Catalogue of Army Medical Museum, p. 455.

[2] Med. and Surg. History of the War of the Rebellion, First Surg. Vol., p. 420.

Fig. 425.



Shot-wound of the external carotid artery, and ligation of common carotid. (Spec. 3969, Sect. I., A. M. M.)

by the losses of blood which had occurred before the operation.

An example of this form of injury that occurred in the lower extremity, will be useful: Colonel Roderick Matheson, commanding the 32d New York Volunteers, was wounded in the battle of Crampton Gap, Maryland, September 14, 1862, the ball passing through his right leg, and fracturing the fibula in its course. Cold water dressings were applied. Six days after the casualty, a slight discharge of dark-colored blood occurred, and two days afterwards was repeated; the whole amount of both hemorrhages did not exceed four fluidounces. No further bleeding appeared until the seventeenth day, when about a pint escaped, not enough, however, to cause syncope. Next day, under chloroform, the coagulum was removed, when considerable hemorrhage followed, coming, as was soon ascertained, from the posterior tibial artery. It was then decided to enlarge the wound and tie the artery in it, which was accordingly done. On exposing the artery, one side of it was found to have been carried away, to the extent of nearly one inch; a ligature was placed around it, both above and below the aperture, a few pieces of bone were removed from the fractured fibula, and the patient was placed in bed. Symptoms of great prostration being present, every possible effort was made to rally him, but without avail. He lived but a few hours after the operation.[1] For two or three months before the casualty the patient had suffered from army-diarrhœa, in consequence of which he was much enfeebled; too much, in fact, to survive the loss of blood and the shock of the operation.

The partial division of large arteries by gunshot missiles, as these cases show, is very dangerous to life. The aperture in the tunics of the injured vessel gapes widely open from contraction of the arterial fibres, but lessening of the vessel's calibre at the place of injury from contraction of the arterial fibres does not occur; retraction of the injured portion into the arterial sheath cannot take place; an internal coagulum, or a clot within the mouth of the wounded vessel, cannot be formed; and the external coagulum adheres so loosely to the mouth of the wounded vessel that sooner or later it becomes displaced, and then either a traumatic aneurism will form, or a hemorrhage will burst forth externally, and the patient will lose his life unless surgical aid is seasonably obtained.

The *perforation* of arteries from side to side, which constitutes the only remaining form of the partial division of arteries that may be caused by gunshot projectiles, is not often met with in the extremities; nevertheless, Professor Alfred C. Post has reported a good example:—

Henry Schatt, aged 30, wounded March 25, 1865, was admitted into Mount Pleasant Hospital April 2, with a gunshot wound of the left thigh. A conoidal ball had passed through the popliteal space from without inward, injuring the popliteal artery. On

[1] American Medical Times, Feb. 28, 1863, p. 101.

the day of his admission, the thigh was amputated by the circular method, under ether and chloroform (mixed). Very little blood was lost. There was good reaction. The toes of the amputated limb were bluish; the foot was cold, and covered with bluish and purple spots. The entire leg was greatly swollen; the superficial veins engorged. Small veins on the inner surface of the thigh were somewhat discolored; the integument presented a yellowish color. The pulse of the patient, at the time of the operation, was small, sharp, and frequent. The face was pale, and the tongue coated. The popliteal artery was found to have been *perforated by the ball*, and to be nearly surrounded by a large traumatic aneurism. The tissues of the posterior part of the leg were infiltrated with blood down to its middle third. The popliteal vein was not injured. There was a slight fracture of the inner part of the head of the tibia. After the operation the edges of the wound were approximated with strips of adhesive plaster, and cold-water dressings were applied. On May 31 the patient was recovering, and it is believed that he ultimately got entirely well.[1]

The symptoms in this case denoted that gangrene of the foot and leg was about to occur, and the performance of amputation was therefore indispensable. Moreover, gunshot wounds involving the popliteal artery are exceedingly apt to be followed by gangrene of the foot and leg; and the cause of this liability will be shown in the sequel.

The following, likewise, is a good example of the gunshot perforation of a large artery:—

The Army Medical Museum[2] possesses an example of perforation, from before backward, of the right primitive iliac artery, by a pistol-ball. (See Fig. 296, Vol. II. page 198.) The patient lived twelve minutes after the reception of the wound, so that, had a competent surgeon been at hand, and had the abdominal aorta and left primitive iliac artery been firmly compressed against the spine immediately after the casualty, so as to stay the hemorrhage for the time being, it would have been possible to tie the vessel above and below the wound with success.

When a large artery is notched or perforated by a gunshot missile, the single orifice that is caused by the notching, or the double orifice that is caused by the perforation of its walls, as the case may be, never heals spontaneously, for reasons which have just been presented; and if the track of the missile through the parts that surround the artery is in such a condition as to allow unrestrained communication between the orifice in the vessel and the exterior of the body, or the interior of one of its great cavities, such as the cavity of the abdomen or that of the thorax, the patient soon perishes from hemorrhage, unless efficient surgical aid is very promptly afforded. In cases where the arterial orifice happens to be primarily closed by bits of clothing, or by the torn and disintegrated tissues themselves, or by blood-clots, the hemorrhage may thus be restrained until the separation of the disintegrated tissues as a slough begins, when the hemorrhage that has been suppressed for some days will reappear, and the patient will perish from the loss of blood, unless surgical assistance be near at hand.

But when from closure of the external wound by pressure, or from closure of the track of the ball by the sliding past each other of muscular planes and fasciæ, which sometimes occurs on altering the position of the injured part, the external hemorrhage ceases, but, at the same time, the internal does not cease, the blood continues to issue from the aperture in the wounded artery with each contraction of the heart, and, finding no vent, accumulates in the surrounding connective tissue, thus forming a diffuse traumatic aneurism which may prove fatal by bursting and bleeding, or by causing gangrene, as occurred in Prof. Post's case above quoted.

[1] U. S. Sanitary Commission Surgical Memoirs, pp. 47, 48. New York, 1870.
[2] Med. and Surg. Hist. of the War of the Rebellion, Second Surg. Vol., pp. 323, 324.

*Treatment of Partially-divided Arteries.*—Arteries when opened or partly divided by gunshot missiles must always be secured in the wound, if possible, by two ligatures, one being placed above and the other below the aperture in the arterial tunics. The artery should also be completely divided between the two ligatures. In the following case this operation was performed on the femoral artery, with a most excellent result:—

Corporal H. C., Co. I., 114th Colored Troops, aged 29, was accidentally wounded at Fort McIntosh, Texas, December 18, 1866, by a conoidal pistol-ball, which entered two inches below Poupart's ligament, and, passing inward, downward, and backward, emerged from the inner part of the thigh three inches below the level of the point where it entered, injuring the superficial femoral artery half an inch below the profunda. When brought to the hospital, he was very faint from excessive loss of blood. Four hours after the accident the wound of entrance was enlarged by incision, the patient being under ether; a tourniquet was applied, and the femoral artery ligated above and below the seat of injury. The wound of exit was then enlarged to favor drainage. On Dec. 31 the patient was doing well. On Feb. 28, 1867, he returned to duty, cured.[1]

Arterial wounds attended with brisk hemorrhage must always have digital compression instantaneously applied either in the wound itself, or upon the proximal portion of the wounded artery, or upon the parent trunk, by methods already described, in such a way as to suppress the bleeding until ligatures can be placed around the injured artery, as just directed. In cases where large arteries like the common carotid, the common femoral, the axillary, etc., are laid freely open by gunshot missiles, compression of the open mouth of the injured vessel, directly and instantaneously effected, with one or more fingers inserted into the wound and kept there until a surgeon can be brought and ligatures applied, affords the only means of saving the patient. In such cases, a delay of but one or two minutes in applying the pressure may be attended with the loss of so much blood as to prove fatal, either immediately by syncope, or after some days by anæmic exhaustion. When the operation of tying the injured artery in the wound with two threads is not practicable, the injured artery itself, or its parent trunk, must be secured by ligating it with carbolized catgut, on the cardiac side of the wound, but as near to it as possible. Under such circumstances, Anel's plan of operating should generally be preferred to that of Hunter; for instance, in a case where the tongue is wounded, the lingual artery should be tied instead of the carotid; or, if the wound involve the external carotid, that artery should be ligated instead of the common carotid, etc. Anæmic exhaustion resulting from hemorrhage should, in uncomplicated cases, be treated by transfusion. In those cases of gunshot arterial lesion where, after the hemorrhage has ceased externally, it continues internally in the shape of an extravasation into the connective tissue, that is, in those cases where a diffuse traumatic aneurism forms, the surgical treatment should, in general, be precisely the same as if the external bleeding had continued; for, in both instances, the lesion to be treated is the same, namely, the arterial wound. When gangrene ensues, our sole expedient is amputation; and this operation should be performed without delay, that is, before the system at large becomes septicæmic in consequence of the passage into it of putrid blood and serum from the gangrenous part.

These three operative procedures, namely, ligation in the wound, ligation on Anel's and Hunter's plan, and amputation, should never be held in abeyance, as expedients of last resort, while other things are being tried; but, on

[1] Circular No. 3, S. G. O., Washington, August 17, 1871.

the contrary, each of them should be promptly performed by the surgeon whenever it is indicated as the best means at his command for saving life.

The treatment of gunshot wounds of arteries, when complicated with gunshot fractures, will be considered hereafter.

Concerning the employment of *styptics*, as, for instance, the persulphate and the perchloride of iron, etc., as hæmostatic agents in hemorrhages from gunshot wounds of arteries, some mention should here be made. In the first place, in the instances where large arteries are opened by musket-balls, etc., they are entirely inadequate to meet the requirements of the case. When the hemorrhage proceeds from small arteries, such styptics, even when aided by local compression and cold, are often worse than useless. Thirteen fatal cases of bleeding from the minor branches of arteries in the upper extremity are reported in the Medical and Surgical History of the late Civil War.[1] In a number of these cases the application of styptics contributed much to the fatal issue.

To imperfect or inadequate ligation several of these deaths must also be directly charged. For example, four cases of ligation of the radial artery in gunshot wounds unattended by fracture terminated fatally:—"It is noticeable that in these four fatal cases proximal ligatures only were applied."[2] All the cases in which the radial artery was secured with distal as well as with proximal ligatures ended in recovery. Of five patients in whom the ulnar artery was tied above and below the lesion, for hemorrhage in gunshot wounds, all recovered but one, and he died of pyæmia. In three instances where the ulnar artery was tied on the proximal side only of the lesion, "two of the three patients died, one having undergone consecutive amputation; the third recovered, after consecutive ligation of the brachial."[3] The surgeon should never forget that, "when the injury is inflicted on an artery near the extremity of a limb, it is *indispensable* to employ the double ligature, on account of the multiplied communications by anastomosing branches." (Dupuytren.)

Thus experience shows that hemorrhage from wounded arteries should not be treated by applying styptics when it is practicable to ligate them; and that a distal as well as a proximal ligature should be placed around the wounded vessel.

Complete Division of Arteries by Gunshot Missiles.—Small arteries are severed in almost every case of gunshot wound; yet this accident but seldom causes troublesome hemorrhage, or any other bad consequence. The bleeding from these small vessels, when they have been completely divided by gunshot projectiles, spontaneously ceases in a short time, as a rule, and does not recur.

Large arteries, too, have sometimes been found severed in the wounds made by small-arms, but not often; much less often than they are found notched or perforated, that is, incompletely divided in such wounds. For the severance of arterial trunks, and of large arteries in general, by rifle or pistol balls, it is especially needful that the missile should be moving with very great velocity at the moment of impact. The same missile proceeding in exactly the same track, but with less velocity, might only notch the artery; moving with still less celerity, it might only bruise the arterial tunics; and, if moving more slowly still, it might leave no trace of arterial injury. The late Dr. Otis justly calls attention to this point. He remarks:[4] "The reader will observe here, as elsewhere, the very large proportion of gunshot wounds of arteries in accidents, assassinations, and suicides, in comparison with those

[1] Second Surg. Vol., p. 460.
[2] Ibid., pp. 452, 453.
[3] Ibid., p. 452.
[4] Circular No. 3, S. G. O., p. 55.

received in battle. In other words, that the great arterial trunks are often divided at very close range by the small projectiles, but very rarely at long range." The velocity of these projectiles is, of course, very much greater at short, than it is at long range. I shall illustrate the principal facts pertaining to the division of arteries by small-arm missiles, by presenting a number of well-authenticated examples. In the first three cases the carotid artery was involved:—

Private James B. Morrissey, Co. B. 34th United States Infantry, was shot through the neck, at Grenada, Mississippi, March 28, 1868. The missile entered two and one-half inches below the lobe of the *left* ear, and emerged on the *right* side of the nape one inch and a half from the spinous processes. The carotid artery was severed, and death was almost instantaneous.[1]

Private George Robinson, Co. D, 40th U. S. Infantry, was shot on August 26, 1868, by the officer of the guard, for mutinous conduct at the United States Army post, Goldsborough, N. C., with a Colt's navy revolver, in the neck, the ball severing the carotid artery. Death from hemorrhage resulted almost immediately, September 13, 1868.[2]

Major John A. Thompson, 7th U. S. Cavalry, was wounded by a pistol-ball while engaged in suppressing an affray between a party of soldiers and desperadoes, near Fort Mason, Texas, on November 14, 1867. The missile struck the right malar bone, and emerged below the left ear, severing the left carotid artery. He was taken to the post hospital, and died the next day, from hemorrhage.[3]

In the following instance the subclavian artery was divided:—

Private James Smith, Co. I, 38th U. S. Infantry, was shot, by the accidental discharge of a Springfield musket (calibre 50), in the hands of a comrade, while standing in the door of the company quarters. The ball entered the right shoulder from behind, and, passing through the scapula, divided the subclavian vessels and fractured the clavicle. Death was almost immediate.[4]

In the next three examples the external iliac artery was severed:—

Private John Gerhardt, Co. K, 2d U. S. Infantry, aged 22, received, on January 9, 1869, accidentally, a gunshot wound of the groin. He was immediately admitted to the regimental hospital, and died one hour afterward of hemorrhage, from the external iliac artery, which was divided in the wound.[5]

Private Winny Abbott, Co. K, 25th U. S. Infantry, committed suicide at Jackson Barracks, New Orleans, August 8, 1869, by shooting himself with his own musket. The ball entered the abdomen two inches above the pubis, and one inch to the left of the linea alba, passing through the rectus abdominis muscle, cutting off the bowel, severing the external iliac artery, and escaping posteriorly through the os innominatum. He expired immediately after receiving the wound.[6]

Corporal R. A., Co. E, 38th U. S. Infantry, aged 35, was admitted to the post hospital at Fort Hays, Kansas, October 21, 1867, in an intoxicated condition, with a gunshot wound of the abdomen; pulse small and feeble, skin cold; was very restless, and vomited several times. Death resulted at two o'clock next morning. *Autopsy*—Thirty-six ounces of fluid tinged with blood, a quantity of coagulated blood, and some fecal matter were found in the abdominal cavity. The ball had wounded the small intestines in two places, passed through the sigmoid flexure of the colon, severed the external iliac artery completely, and the vein partially, etc., and lodged in the gluteal muscles.[7]

In the next two cases the femoral artery and vein were divided:—

Henry C. Clinton, artificer, Co. C, 2d Infantry, was shot in a street-brawl at Louisville, Ky., October 19, 1868, through the right thigh, by a round pistol-ball, which

[1] Ibid., p. 21. [2] Ibid., p. 22. [3] Ibid., p. 23.
[4] Ibid., p. 23. [5] Ibid., p. 55. [6] Ibid., p. 55. [7] Ibid., p. 55.

passed obliquely through from behind, severing the femoral artery and vein at the point where the artery passes through the adductor magnus. Death occurred in a few minutes from hemorrhage.[1]

Private William Neff, Troop B, 9th Cavalry, was admitted to hospital at Fort Stockton, Texas, in a moribund condition, having bled almost to death from a gunshot wound of both thighs. A tourniquet was put over each femoral artery. The patient's condition precluded an operation for ligating the injured vessels. The autopsy showed the femoral artery and vein to be severed.[2]

Thus, I have briefly presented *nine* cases in which large arteries were completely divided by rifle or pistol-balls. *Eight* of them perished from the primary hemorrhage. In some, death was almost instantaneous; in others, it occurred in some minutes; and in a few at the end of some hours; but, in almost all, death occurred in a very short time. Digital compression applied in the wound immediately after the casualty, and continued until the ends of the severed artery can be securely tied, affords almost the only means of saving such patients.

But *one* of these nine cases survived the primary hemorrhage. He lived until the eighteenth day, when secondary hemorrhage supervened, and carried him off almost immediately. In the following example, also, death ensued from secondary hemorrhage:—

James Brown, 3d Tennessee Mounted Infantry, was shot through the right thigh, just below Poupart's ligament, obliquely from before backward, at the battle of Chickamauga; the wound involved the track of the femoral artery, but not the bone. The man was taken to the field hospital; no pulsation could be felt below the wound, and it is therefore believed that the common femoral artery was divided; there was then no bleeding of consequence, so the case was left to nature, and the patient did well for six days, when hemorrhage suddenly supervened while he was at stool. Liquor ferri persulph. was immediately injected into the wound, and compression applied, but without success. The external iliac artery was then ligatured, under chloroform, by Sir A. Cooper's method. But the patient never rallied from the loss of blood; he gradually sank, and died from anæmic exhaustion on the seventeenth day after the operation.[3]

For secondary hemorrhage in such cases, digital compression, applied without delay in the wound, and kept up until the ends of the severed artery are secured with ligatures, is the proceeding which must be employed, for it is about the only one that can rescue the patient.

Gangrene has often been observed in patients who had survived the shock and the primary bleeding incident to the division of large arteries by small-arm projectiles, and I shall present several examples in point:—

Private C. Gross, Co. K, 6th Pa. Cavalry, wounded May 30, 1864. A minié-ball passed through both thighs at the middle, from left to right, dividing also the left femoral artery, but without injuring the bone. Patient lay in the woods for twenty-four hours; hemorrhage occurred several times, which he partially controlled by making pressure with his fingers. May 31 he was discovered, and taken to the field hospital, where the severed artery was cut down upon, and both ends tied. June 4, he was admitted to Stanton Hospital, under my care; countenance pallid; pulse weak; limb very much swelled, œdematous, and presenting dark patches of extravasated blood around the groin. On the 5th secondary bleeding occurred to moderate extent, and was arrested by ferri persulph., etc. It recurred, and was arrested by digital compression. On the 8th his foot became gangrenous, and the gangrene spread upward. On the 9th he died. *Autopsy*—Limb very much swollen; muscles extensively infiltrated with pus from groin to knee; femoral artery severed about its middle; both ends tied, but the distal ligature had slipped off; femoral vein also found liga-

[1] Ibid., p. 78. [2] Ibid., p. 85.
[3] U. S. Sanitary Commission, Surgical Memoirs, vol. i. p. 51. New York, 1870.

tured with a separate thread. All the viscera were normal.[1] The gangrene appeared on the tenth day after the casualty.

Dr. J. C. Baylor, of Norfolk, Va., has reported another example: J. W. Dinguid, wounded by a minié-ball on June 1, 1864. Femoral artery severed in its lower third; no consecutive hemorrhage; died on the 15th, fourteen days after the injury. *Autopsy* —Gangrene of foot had commenced; wound in thigh a sloughy mass; no effort at repair.[2]

In both of these cases the gangrene was late in making its appearance: in the first on the tenth, and in the last about the thirteenth day after the casualty. Both patients appear to have been sunk into so low a state from anæmic exhaustion that amputation was not admissible when gangrene set in.

In the next four examples the severance of the *popliteal artery* was followed by gangrene in three instances:—

Private James H. Dutcher, 2d N. Y. Heavy Artillery, aged 24, was admitted to Stanton Hospital, under my care, June 4, 1864, from the field, having been wounded on May 31 by a conical musket-ball which passed through his left knee from before backward, and involved the track of the popliteal artery. Being very low, and the leg already gangrenous, he was placed on supporting treatment to prepare him for successful amputation, if possible. June 5—Foot and leg greatly swelled, dark-brown in color, and emitted an offensive, gangrenous odor. Thigh much swollen and hot; also extensively ecchymosed, and the swelling extends up to the groin. No line of separation yet appears. Countenance pale and anxious, pulse frequent and weak; general debility great. He was perfectly clear-minded, and expressed a strong desire to have the gangrenous limb removed. I accordingly at once, under ether, amputated it high up in the upper third of the thigh by the flap method; femur sawed off three-fourths of an inch below the trochanter minor. The shock of the operation was very great; reaction established with difficulty, and not complete until the next day. Dissection of the amputated member showed that the popliteal artery was completely divided by the bullet, just above its termination in the anterior and posterior tibials. June 6—He is feeble, pale, and anæmic. June 7—Condition unchanged; pulse about 90, and weak, notwithstanding that he receives all possible support from nutrients, tonics, and stimulants. June 8—No improvement; stump sloughy. He sank and died at 11 P. M. He also had obstinate vomiting with hiccough on the last day.

The hemorrhage in this man's case ceased spontaneously. It must, however, have been considerable, for it left him in a state of anæmic exhaustion from which he never recovered. His death, too, was hastened by septicæmia; or by the fact that his system was contaminated with the decomposing fluids which readily passed into it from the gangrenous leg, as no line of separation formed between the dead and the living tissues.

Private Sam. C. McCreary, 100th Penna. Vols., aged 24, was wounded at Chantilly, Sept. 1, 1862, by a ball which passed through the right popliteal space, having entered about three inches above the insertion of the biceps flexor cruris, passed immediately behind the femur, and emerged through the inner hamstring muscles, chipping out a small piece of the inner condyle, and dividing of course the popliteal artery. He lost a great deal of blood on the field, but the hemorrhage ceased of itself. On the fourth day afterward, he entered hospital at Alexandria, Va., in a very feeble condition and presenting an ensanguinated appearance; no pulsation in either tibial artery, and the leg itself cold. Gangrene followed, beginning at the toes. On Sept. 13, the limb was amputated four inches above the knee, under chloroform, by the flap method. For nearly three weeks after the operation, the patient's life was almost beyond hope; there was almost total anorexia, and large bed-sores formed about the sacrum. Under stimu-

[1] Ibid., pp. 53, 54, 57.
[2] American Journal Med. Sciences, 1865, p. 254.

lants, tonics, and nutrients, however, the patient slowly recovered, and on Dec. 4 left the hospital with his father, the stump being nearly healed.[1]

The above is the almost exact prototype of a case of wound of the popliteal artery, which occurred at the battle of Chickamauga, with similar treatment and results.[2]

Private W. D. Thompson, Company E, 5th Cavalry, aged 40; gunshot wound (minié) of left knee-joint, ball entering outer portion of popliteal space, traversing inner condyle, and emerging at inner side of joint; popliteal artery completely divided; no consecutive hemorrhage; no effort at repair in the wound. Wounded May 5, died May 18, thirteen days after the casualty. Case reported by Dr. J. C. Baylor, of Norfolk, Va.[3]

Thus, I have briefly presented four cases in which the popliteal artery was severed by minié-balls. In all of them the hemorrhage ceased spontaneously; but in each the loss of blood appears to have been great, and to have caused anæmic exhaustion. In three of them gangrene of the foot and leg occurred in consequence of the arterial wound. In the remaining case, if gangrene did not appear, the fatal issue was probably due to anæmic exhaustion. Amputation of the thigh saved two of the three patients attacked with gangrene. But why is gangrene so apt to follow the severance of the popliteal artery by small-arm projectiles? The anatomical structure of the parts furnishes a good reason. When the popliteal artery has been divided in a gunshot wound, the foot and leg must derive their supply of nutrient blood through the collateral channels, which are the several articular branches at the knee, and they are so small as to afford, at best, but very scanty facilities for establishing a collateral circulation. But, in cases of gunshot wounds involving the popliteal space and parts bordering thereon, the inflammatory swelling, which always attends such wounds in this region, diminishes still further the supply of nutrient blood to the foot and leg by compressing the collateral channels at the knee; at least, the compression exerted by this inflammatory swelling is very liable to prevent the collateral channels at the knee from undergoing that development or expansion of calibre which is requisite in order to furnish such a supply of nutrient blood to the foot and leg as will preserve their vitality after the popliteal artery is severed. Gunshot wounds dividing the popliteal artery must therefore be classed among the most troublesome as well as among the most dangerous wounds in surgery. In order to achieve a successful treatment of such cases, the indications are twofold: First, the primary bleeding must be arrested at the outset, so that the occurrence of exhaustion from the loss of blood, or anæmic exhaustion of a fatal character, may be prevented, by the employment either of digital compression, or of Esmarch's elastic ligature. Secondly, the leg should be amputated at the knee-joint, during the primary period, before the patient becomes worn out by his sufferings, and before gangrene of the leg, with its attendant septicæmia, has occurred.

I shall next relate two cases in which the *posterior tibial artery* was severed by cylindro-conoidal musket-balls. In one of them there also was fracture of the fibula; in the other the bone was uninjured. In both, however, the arterial wound was the principal lesion. In both traumatic gangrene occurred. In both, likewise, the primary hemorrhage ceased spontaneously.

Private Conrad Kogel, Co. D, 15th U. S. Heavy Artillery, aged 39, was admitted to Stanton Hospital, under my care, June 4, 1864, having been wounded at Mechanicsville, May 30, by a minié-ball, which passed nearly transversely through the calf of his right leg, from without inward, and somewhat upward. When admitted, his leg

[1] U. S. Sanitary Commission Surgical Memoirs, vol. i. pp. 57, 58. New York, 1870.
[2] Ibid., p. 58.
[3] American Journ. Med. Sciences, 1865, p. 254.

was very much swelled and inflamed up to the knee. No tibial pulse could be felt at the ankle. He had much constitutional disturbance, and was very restless. The ice-dressing was applied to his leg; nutrients and tonics were administered. June 6—Leg still more swelled, and beginning to mortify in spots; constitutional state worse, and there is irritative fever of a low type. Amputation being the only resource left, it was without delay performed at the lower third of the thigh, under ether, by the circular method. The shock was moderate, and the patient reacted promptly. Examination of the amputated member showed the posterior tibial artery divided by the bullet. The operation afforded much relief until June 10, when the flaps began to slough. He then sank into a so-called typhoid condition. June 15 (evening)—He had a pyæmic chill, after which he sweat profusely. June 16—He had two rigors, and the sweats continued. His countenance had become sallow, and he was delirious. In the evening he died. The *autopsy* revealed the lesions belonging to gangrenous osteo-myelitis and pyæmia, a description of which want of space excludes.

Lieutenant-Colonel W. G. Delaney, a prisoner of war, was admitted to Stanton Hospital, under my care, September 25, 1863, having been wounded on the 23d by a conical musket-ball, which entered his left leg on the outer side, about two inches below the head of the fibula, fractured that bone with comminution, and emerged, after crossing the track of the posterior tibial artery a short distance below its origin. The casualty was attended with considerable hemorrhage, but this ceased spontaneously, and did not return. When admitted, the patient had considerable fever of an irritative type, some œdematous swelling of the leg, and no pulsation in the posterior tibial artery at the ankle. The swelling of the leg increased, and gangrene ensued, but the patient's general condition was so bad as not to warrant the performance of amputation. On Oct. 2 he died. The *autopsy* showed the posterior tibial artery to have been completely divided by the bullet, about one inch below its origin at the bifurcation of the popliteal; there was fracture of the fibula with considerable comminution. No line of separation had been formed.

Wounds inflicted by cylindro-conoidal musket-balls which sever the posterior tibial artery in the upper third of the leg, are often, perhaps generally, attended with consecutive gangrene. The reason is twofold: first, the division of the artery cuts off the supply of blood which is needed by certain parts of the limb. Secondly, the inflammatory swelling attending such wounds is always great, especially when the arterial wound is complicated with fracture. This swelling involves the tissues which are covered or bound down by the deep fascia of the leg, as well as those external to it. As this fascia is very strong, and cannot give way, the inflammatory tumefaction beneath it compresses the anastomosing branches to such extent, and with such force, that a collateral circulation cannot be established, and thus the parts below perish from want of nutrient blood. Wounds such as these demand that amputation at the knee-joint shall be performed either primarily, or as soon as gangrene presents itself in the toes or foot. If the operation be delayed after the appearance of gangrene, the risk of septicæmia will be correspondingly increased.

In the following example, the *axillary* artery was divided by a cylindro conoidal musket-ball; the hemorrhage was not troublesome, but gangrene of the hand, forearm, and arm ensued, and destroyed the patient:—

Private T. H. Hudson, a prisoner of war, aged 21, was admitted to Stanton Hospital, under my care, May 18, 1864, having received two wounds from minié-balls at Spottsylvania, Va., on the 11th. One of them entered his left shoulder from behind, and escaped in front a little way below the clavicle, having crossed the course of the axillary artery. The other penetrated his right hip near the sacrum, and emerged in front near the right groin. The hemorrhage was not troublesome from either wound. On admission, the patient's condition was good, and his wounds looked well. It was observed that there was no brachial nor radial pulse on the left side, and it was supposed that the left axillary artery had been severed. May 22—The wounds

appear to be doing well, but the left hand, forearm, and lower part of arm have become much swollen and dark in color. No pulsation in brachial, radial, and ulnar arteries. May 28—The gangrene is still progressing, and the mortified tissues of the forearm are exulcerating. June 1—The gangrene is limited at middle of arm. The gunshot wounds look well, but still the patient is obviously failing; he is emaciated; appetite poor; tongue dry; some diarrhœa. He continued to sink, and on June 6 he died. At the *autopsy*, the axillary artery was found completely divided by the bullet, and its two ends retracted or separated two inches from each other. Both ends were securely plugged up. The axillary vein and the brachial plexus of nerves were not wounded.

Although this patient's general condition was so bad that amputation did not seem justifiable at any time after gangrene appeared, still, on reviewing the case now, I am inclined to think that the operation might have somewhat improved his chance of recovery, especially if it had been performed in the upper part of the arm as soon as the gangrene presented itself in the hand. This plan of treatment I now recommend, and shall hereafter follow, namely, that, when gangrene occurs in consequence of division or obstruction of the axillary artery, amputation is to be practised in the upper third of the arm as soon as the hand is attacked.

The hemorrhage not unfrequently ceases spontaneously in cases where the axillary artery is divided in wounds made by musket, carbine, or pistol-balls. I shall relate another example which came under my own observation, in speaking of traumatic aneurism. The elder Larrey reported the case of General Dulong, who was wounded in the right axilla by a small-arm projectile. Although there was scarcely any hemorrhage, there was good reason to believe that the axillary artery had been divided. Dr. James M. Holloway[1] records a case in which a minié-ball passed through the left axilla from behind forward, crossing the track of the axillary artery. The bleeding ceased spontaneously, although there is good reason to believe that the artery was severed. That which was found on autopsy to have occurred in Hudson's case, related above, shows how the natural hæmostasis may succeed in such cases. The tunics at each end of the divided artery retract, recurve, and contract, whereby the orifices become much smaller, and a secure lodgment is afforded for the occluding plugs of clotted blood. "M. Verneuil communicated to the Surgical Society of Paris five cases of injuries of large arteries by balls and pieces of shell, in which hemorrhage was arrested spontaneously. The performance of primary amputation allowed the state of the vessels to be examined. The arterial coats were divided throughout on the same level as if they had been cut by a knife, and clots extended for some way above the divided ends of the vessels. In two of the cases the posterior tibial and the popliteal were the injured vessels."[2]

In the following example the *brachial artery* was severed in a wound made by a musket-ball. The primary bleeding was so slight as to escape mention. Eighteen days afterward secondary hemorrhage supervened, and was permanently arrested by securing both ends of the severed artery with ligatures.

Private W. J. Beverley, Co. C, 17th Maine Vols., aged 27, was admitted to Stanton Hospital May 23, 1864, on account of secondary hemorrhage from a gunshot wound of his right arm, with which he had been attacked in the streets of Washington while on his way homeward on furlough. On May 5, at the battle of the Wilderness, a musket-ball had penetrated his right arm just above the flexure of the elbow, and, passing behind the biceps muscle, had escaped on the inner side of the arm, without injuring the bone or causing much loss of blood. The secondary hemorrhage was arrested by pressure applied to the seat of injury. On the evening of the 24th, however, it returned. The brachial artery was then cut down upon at the seat of injury, and found completely

[1] American Journal of the Medical Sciences, October, 1865, pp. 352, 353.
[2] Gaz. Méd., Juillet 22, 1871, and New Syd. Soc. Biennial Retrospect, 1871, 1872, pp. 263, 264.

divided by the projectile. Both ends of the vessel were securely ligatured, and the hemorrhage did not recur. May 26—A slight recurrent pulse can be felt in the radial artery. June 16—The wound of operation has healed, but purulent matter has extensively burrowed among the muscles of the forearm, necessitating an incision about six inches long to relieve the burrowing. Pyæmia supervened, and, on July 2, the patient died of pyæmic pneumonia. The *autopsy* showed visceral abscesses in the lungs, liver, etc.

Two additional cases in which the brachial artery was divided in wounds made by musket-balls, are recorded in the U. S. Sanitary Commission's Surgical Memoirs, vol. i. In one of them the missile struck the left arm near the junction of the upper and middle thirds, severed the artery, and shattered the humerus for four inches; for a moment or two the bleeding was profuse, but it ceased spontaneously. The arm was amputated, two inches below the head of the humerus, four hours after the casualty. The patient recovered. In the other case, the ball passed through the anterior and inner aspect of the right arm, and directly across the course of the brachial artery. When brought to the field hospital there was no pulsation at the wrist; sensation and motion were impaired. There had been no hemorrhage excepting slight capillary oozing. No pulsation was detected by passing a finger into the wound. The shock was very great, with tendency to syncope. No secondary bleeding occurred, and the patient got well without giving much trouble.[1]

In neither of these three cases of complete division of the brachial artery by musket-balls was the primary hemorrhage excessive. It was suppressed in each instance, also, with great promptitude, by the proeesses of nature.

Arteries of medium calibre, that is, belonging to the next subdivision after the brachial, very often, perhaps generally, cease spontaneously to bleed when eompletely divided in wounds made by musket-balls, ete., as happened with the internal epigastric arteries in the following instance:—

A prisoner of war was shot by the guard while attempting to escape. The bullet went into one inguinal region and emerged from the other, cutting through the entire abdominal wall, from side to side, about half an inch above the pubis. It severed the epigastric artery on either side (the ends were visible), and produced a gaping wound about eight inches in length, plainly exposing the pelvic viscera. There appears to have been no bleeding. Three weeks afterward the patient was returned from the hospital, convalescent, to the military prison.[2]

But the bleeding does not always cease spontaneously in such eases, as the following example shows:—

Private A. Y., Co. D, 23d Infantry, received a severe gunshot wound of the wrist-joint, in a skirmish with Indians, April 29, 1868. The radial artery, being lacerated, was ligated above and below the seat of injury, and water dressings were applied to the wound. In July, 1868, the patient returned to duty.[3]

The observations presented above show that gunshot wounds dividing large arteries are not only very dangerous, but also destroy life in certain determinate ways, the principal of which are primary hemorrhage, secondary hemorrhage, and consecutive gangrene. Gangrene ensues after such wounds much oftener than many suppose; I have presented eight examples of it, five of which passed under my own observation, and have seen several other examples of which unfortunately I did not take notes.

As this subject (traumatic gangrene) possesses much importanee in this eonnection, I have taken some pains to collate Guthrie's experience eoncerning gangrene following gunshot wounds of bloodvessels. It appears that he saw seven cases belonging to this category in military practiee. In three of

[1] Op. cit., pp. 69, 70.
[2] Med. and Surg. History of the War, Second Surg. Vol., p. 175.
[3] Circular No. 3, S. G. O., pp. 237, 238.

them the popliteal artery was involved. In two of these three cases it was found, on dissection, that there was complete division of the artery; in the other case it was surmised that there was complete division of the artery, but no autopsy was made. In the remaining four cases it was believed that the femoral artery was wounded by a musket-ball in every instance; but it was not known that the artery was completely divided in any of them. Of these seven cases observed by Guthrie, then it appears that, as far as known, the vessel was completely divided in but two instances, both pertaining to the popliteal artery. Amputation was resorted to in two instances, but without avail. Every one of these seven cases proved fatal.[1]

Guthrie also stated that he had seen, in London, three cases of gangrene following wounds of the femoral and popliteal arteries; in two the popliteal, and in one the femoral was the injured vessel. All proved fatal from the extension of the gangrene.[2]

The principal cause of the great fatality which attends traumatic gangrene, is the fact that a line of demarcation, or separation of the dead from the living tissues, is but seldom formed in such cases. This circumstance is also noticed by Guthrie. The consequence is, that the veins which proceed from the gangrenous part toward the trunk, not being closed or obliterated as they would be if a line of separation were formed, convey the decomposing blood and other putrescent liquids from the gangrenous part, and pour them into the current of the general circulation. Thus, systemic poisoning of a septic character, or septicæmia, is produced, and the patient's life is destroyed; and the earlier the date may be when the gangrenous part is removed from the body by amputating it, the less will be the degree of the septicæmia.

*Symptoms of Complete Arterial Division.*—The symptoms which indicate that a large artery that lies in or crosses the track of a gunshot wound is completely divided, are, brisk hemorrhage, and the disappearance of pulsation in the injured vessel and its branches below or beyond the wound. In cases where there is such absence of pulsation, but no hemorrhage, there may be some doubt as to whether the lesion consists of complete division of the artery, or complete obstruction of its canal from recurvation of its severed inner and middle coats or from plugging with coagulum. But such an occlusion from plugging, without division of the external tunic of the artery, is a very rare occurrence in the history of wounds made by small-arm missiles, however frequently it may be met with in cases where arteries are stretched or bruised; and it should be estimated accordingly.

*Treatment.*—When a large artery is completely divided in a gunshot wound, the *first indication* is to suppress the primary bleeding, without delay, by digital compression, and to restrain it in this manner until the ends can be found and secured by a carbolized catgut ligature applied to each of them. The method in which digital compression can be most effectually employed in such cases, consists in placing both index fingers, or a thumb, in the wound, and applying them directly to the ends of the bleeding vessel. In this way the hemorrhage can be arrested with promptitude, with certainty, and with but little effort; for only a slight degree of pressure is required to arrest the flow of blood, if applied directly to the bleeding orifice of the artery. I say again that, in this way, the hemorrhage from gunshot wounds involving the arteries of the neck, armpit, and extremities, may readily be controlled by any person of ordinary intelligence, until surgical assistance can be obtained, and the injured vessel can be properly ligated. Moreover, the compression,

[1] Diseases and Injuries of Arteries, pp. 235–243. [2] Ibid., p. 245.

to be of much use in such cases, must be promptly applied; otherwise, so much blood will be lost as to prove fatal by anæmic exhaustion, if not by syncope. Both ends of the severed artery must be tied with carbolized catgut. The following example will usefully illustrate the subject of ligating the smaller arteries which may be severed in gunshot wounds:—

Private W. Jess, Troop M, 7th Cavalry, received Nov. 21, 1868, a gunshot wound of right forearm at the middle. The ball passed between the radius and the ulna without fracturing either. No hemorrhage occurred until the fifth day; afterward, hemorrhage occurred about every twenty-four hours, generally at night, from a few ounces to a pint at a time. When the dressings were removed the hemorrhage would cease; an operation was consequently delayed from day to day, in the hope that it would be unnecessary. The arm began to swell, became painful, tense, and glossy, and from above the elbow to the shoulder was swollen and œdematous. On Dec. 5, a deep incision, four inches long, was made lengthwise at the wound. A large quantity of clotted blood was thrown out from between the muscles, which had been dissected up by it in every direction. The interosseous artery was found severed, and both ends of it were tied. The pain was immediately relieved, and the swelling rapidly disappeared. No bad symptoms occurred, and the patient was returned to duty in January, 1869.[1]

The *second indication* in the treatment of cases where large arteries are divided in gunshot wounds, is to anticipate and prevent the occurrence of secondary hemorrhage. Should the ends of the severed artery be sought for and tied, in such cases, when they are not bleeding? Secondary hemorrhage when it occurs in such cases is almost always fatal; and, inasmuch as the best method of preventing secondary hemorrhage from wounded arteries consists in properly tying them, I do not doubt that, in most cases where large arteries are divided in gunshot wounds, their ends should, if practicable, be brought into view by making the necessary incisions, and carbolized catgut ligatures should be applied to both the proximal and the distal ends, although they are not bleeding at the time. Had this been done in three of the cases presented above, where secondary hemorrhage occurred and death ensued, namely, that of George Robinson, whose carotid artery was divided, that of James Brown, whose femoral artery was severed, and that of W. J. Beverley, whose brachial artery was cut across, there is good reason to believe that all of them would have been saved.

Furthermore, I hold that, in every case of gunshot injury where there is reason to believe that large arterial trunks have been damaged, even when they are not divided, a careful search should be made; and should it prove that such is the case, they should be tied with antiseptic ligatures, whether bleeding or not, to render them secure against the effects of reaction and the occurrence of secondary hemorrhage. These proceedings, and the taking care to tie the ligatures in such a way that they cannot slip off from the ends of the artery, constitute the chief surgical means of fulfilling the second indication.

The *third indication* in the treatment of such cases consists in anticipating the occurrence and obviating the effects of gangrene. Whenever the femoral, popliteal, or posterior tibial artery in the upper third of the leg is severed in a gunshot wound, there is much greater risk of the occurrence of gangrene than of secondary hemorrhage; and gangrene is more fatal than even secondary hemorrhage in such cases. For out of eighteen cases of gangrene caused by gunshot wounds of arteries, related or referred to above, all ended fatally save one, and in this the patient was saved by amputation. The great danger of this form of gangrene is because of the very great liability to the occurrence of septicæmia from the non-formation of a demarcating line, as I have just shown

[1] Circular No. 3, S. G. O., p. 238.

above. The only way to obviate the deadly consequences of such a gangrene, and notably the septicæmia, is to remove the mortifying part by amputating the limb at the summit of the region deprived of nutrient blood by the arterial wound; and, the earlier the operation is performed, the less the degree of septicæmia, and the greater the hope of a successful issue. Hence, as soon as the toes become gangrenous in consequence of a severance of the posterior tibial or the popliteal artery, the leg should be amputated at the knee-joint; or, if in consequence of a severance of the femoral artery, the thigh should be amputated above the seat of the arterial lesion. In the upper extremity, as soon as the fingers mortify in consequence of a gunshot severance of the axillary artery, the arm should be amputated at the shoulder-joint or within two or three inches thereof. It is a still better practice, however, to remove by primary amputation the parts in which we know from experience that gangrene will almost certainly ensue; for instance, in cases of gunshot severance of the popliteal artery, or of the posterior tibial in its upper third, especially if the bone be also implicated, primary amputation ought generally to be performed. Under a policy of delay in such cases, gangrene almost always ensues. Primary amputation, by anticipating and averting the occurrence of gangrene and septicæmia, gives the patient the best possible chance to recover.

When gunshot severance of the femoral artery is complicated with gunshot fracture of the thigh bone, I believe it is always best to amputate without delay, because gangrene is almost certain to ensue if the limb be not cut off, and because amputation in the primary period is much more likely to prove successful in such cases than amputation performed in the inflammatory period, or after the appearance of gangrene. When gunshot severance of the posterior tibial artery is complicated with gunshot fracture of both bones of the leg, I believe it is generally preferable to employ primary amputation, especially in military practice in the field. In civil life, however, where the circumstances are usually much more favorable for conducting the after-treatment, it may be advisable to attempt to save the leg when the comminution is not extensive, and the laceration of the soft parts not great, and especially if only one bone be broken. In such a case, occurring under circumstances favorable for treatment, it may be advisable to tie both ends of the artery in the wound, and then to treat the case as a gunshot fracture, with antiseptic dressings.

When gunshot severance of the brachial artery is attended by gunshot fracture of the humerus, the chances of treating the case successfully, without amputation, are generally much greater than in corresponding lesions of the lower extremity. When the broken humerus is but little comminuted, the soft parts surrounding it but little torn, and the accompanying nerves uninjured, it is generally advisable to tie both ends of the artery, and attempt to save the arm. But when the comminution is extensive, and the laceration of the soft parts great, the brachial artery also being severed, primary amputation should be performed. In gunshot fractures of the forearm associated with corresponding wounds of arteries, however, it is but seldom necessary to amputate, unless the elbow-joint be implicated; in such a case it is generally advisable to amputate without delay.

Again, when a gunshot wound of the femoral or popliteal artery is attended with a corresponding lesion of the vein and nerve, although the bone be uninjured, primary amputation should always be performed.

Antiseptic dressings should always be employed, and thorough drainage of the wound should be secured by using Chassaignac's drainage-tubes, etc., in all cases where arteries are involved in gunshot lesions.

The inapplicability of styptics, such as the persulphate and the perchloride of iron, etc., to the treatment of hemorrhage from gunshot wounds of arteries, has already been pointed out. (See page 175.)

## Incised Wounds of Arteries.

The incised wounds of arteries are inflicted with knives of various sizes and shapes, with sharpened swords or sabres, and with many of the edge-tools used in the mechanic arts. A sharp cutting instrument cleaves the tissues with the least possible disturbance of their histological elements, and leaves the opposing surfaces of the section or wound smooth, even, or level, and in the best possible condition for speedy and perfect reparation. But the same circumstances favor the outflow of blood; for the smoothly divided vessels present no such mechanical obstacles to hemorrhage, at their open mouths, as are seen in most other wounds. The incised wounds of arteries are inflicted in accidents, with design, and in war.

When arteries are invaded by cutting instruments, the lesion consists either of a complete division of the arterial tube, or of a partial division, or of a division of the sheath and the external tunic only, or of a mere puncture of all the arterial tunics. But the punctured wounds of arteries are often caused by instruments other than cutting ones, and therefore this form of injury constitutes a separate class, which we have already attentively considered.

The incised wounds of arteries are more prone to bleed than the contused, or the lacerated, or the gunshot wounds, for reasons just stated above. The hemorrhage but seldom, if ever, ceases spontaneously when large arteries are severed by sharp-edged instruments, unless death is at hand, and there is no longer any blood to flow away. But the bleeding from the contused, and the lacerated, and the gunshot severance of arteries, having a similar size, not unfrequently stops of itself, as we have already shown. Incised wounds of arteries are characterized as a class by excessive hemorrhage; and they are more liable as a class to produce death by primary bleeding than any other form of vascular injury.

When a small artery is but partially divided by a cutting instrument, it is always more difficult to stanch the hemorrhage than it is when the same vessel is completely divided. Thus, in abstracting blood from the temporal artery (arteriotomy), when it becomes necessary to stop the bleeding, the first thing to be done is to completely divide the artery at the place where it has been opened, and then a moderate amount of pressure applied for a short time at the place of division will generally suffice to permanently suppress the bleeding. But, if the division of the artery be not made complete in such a case, if pressure be applied for the purpose of arresting the outflow of blood while the arterial tube is only partly divided, then it generally follows that either a traumatic aneurism is formed in the wound, or secondary hemorrhages successively ensue, which may place the patient's life in great peril, even where an artery as small as the anterior branch of the temporal is the vessel involved in the lesion. In cases of incised wounds in general, where the hemorrhage from small arteries that are but partially divided gives trouble, the first thing to be done for suppressing it is to complete the division of the bleeding vessels. Thus we perceive that the treatment of the incised wounds of arteries must be conducted on principles somewhat different from those which obtain in treating the contused, the lacerated, and the gunshot wounds of arteries.

The two following examples usefully illustrate what takes place when a

large artery is completely divided in an incised wound, and the case is left to Nature:—

William Barren, a sailmaker, aged about 32, was stabbed in the throat, and in other places, in an affray, on Saturday night, December 11; he bled very profusely from the throat-wound, and expired in about twenty minutes from the hemorrhage. *Autopsy*, at the Fourth Ward Station-house, December 13, by the author, at twelve M.—Face, lips, gums, and surface of whole body pale and exsanguinated. On left side of neck was found an incised wound, two and a half inches in length, commencing anterior to the ear, and extending forward and somewhat obliquely downward, just beneath and nearly parallel to the body of the lower jaw; its lips were drawn together and held by one suture; the lips of the wound were somewhat irregular in shape; the track of the wound extended almost transversely across and nearly through the throat, severing, in its course, the anterior third of the sterno-mastoid muscle, the left *external carotid artery* near its origin, and the accompanying vein; it also passed through the muscles at the root of the tongue, cutting off the epiglottis at its base; it divided the great cornu of the hyoid bone on the right side, and terminated near the anterior margin of the right sterno-mastoid muscle. Some clotted blood was found in the larynx below the rima glottidis. The stomach contained a few ounces of a substance resembling coffee-grounds. Internal organs generally exsanguinated, but otherwise sound.

The ends of the severed external carotid artery were somewhat contracted, but still permeable, and not plugged up with coagulated blood. The wound in the neighborhood of the vessel contained clotted blood. (The parts of the record not pertinent are omitted.)

John Heavy, middle-aged, was cut in the upper and inner part of his right arm with a knife, and died from the hemorrhage in fifteen or twenty minutes—in not less than fifteen nor more than twenty minutes—on the night of May 3. *Autopsy* by the author, at the Fourth Ward Station-house, on May 4, at 4 P. M.—Cadaver large and muscular; face, lips, and surface of body generally very pale, and presenting a waxen appearance. There was an incised wound of the integuments on the antero-internal part of the right arm, just below the fold of the armpit, one inch and a quarter in length, and extending obliquely across the arm. It was about two inches in depth, and involved the *brachial artery*, which had been severed transversely near its origin. The ends of the divided vessel were partially contracted, but not plugged up with coagulated blood. The wound of the soft parts exterior to the vessel was filled with clotted blood. The lungs, liver, spleen, and internal organs in general, contained much less than the normal quantity of blood; heart large and fatty, with some blood in its right cavities. (Some immaterial points are omitted.)

In neither of these cases was any effort of importance made to suppress the bleeding. The largeness and smoothness of the gash in the integuments and other parts exterior to the artery, allowed the blood to escape unobstructedly from the arterial lesion, in both instances. Careful inquiry was also made by the author, for the purpose of ascertaining how long each man lived after he was stabbed. As both cases were thoroughly investigated by the coroner, unusual facilities were afforded for pursuing this inquiry. The witnesses agreed in testifying that in the external carotid case the man expired in about twenty minutes, and in the brachial artery case in fifteen or twenty minutes—in not less than fifteen nor more than twenty minutes—after the gash was made. In both instances the ends of the severed arteries were somewhat contracted, but they were still open, and not filled or plugged with coagulated blood. In each instance, however, the gash in the soft parts exterior to the vessel was filled with clotted blood. In such cases, as the pulsations of the artery become weaker and the coagulability of the blood increases, the external wound becomes filled with a coagulum, in the middle of which a channel remains open, through which the blood continues to trickle until the clot becomes stronger than the current of the blood, that is,

until the clot coheres with more force than the impulse which the blood receives from the almost empty artery; but when the hemorrhage thus ceases, death is usually very near.

How can such arterial wounds be successfully treated? In cases where either of the *carotids* is involved, pressure must be applied, without delay, by both index fingers or a thumb, in the wound, to the ends of the orifice in the wounded artery, until it can be securely tied with carbolized catgut, above and below the lesion. (Consult also on this point the case of a miller, stabbed in the neck with a pocket-knife, who was successfully treated on this plan, p. 111; and the remarks on the treatment of punctured wounds of arteries on p. 117.) In cases where the *brachial artery* is opened by an incised wound, the bleeding must be promptly suppressed by digital compression, or by an extemporaneous tourniquet, or by Esmarch's elastic ligature, until the artery can be tied above and below the wound. In the following instance this was done with tourniquets extemporized with pocket handkerchiefs:—

An insubordinate soldier, aged 26, while in liquor, resisted arrest and attempted to use violence, whereupon one of the provost guards stabbed him with his sword in the upper part of the left arm, the wound corresponding to the lower third of the coraco-brachialis muscle. Profuse hemorrhage followed, and was arrested by the corporal of the guard, who applied a handkerchief tightly above and another below the wound. This was so cleverly done that the patient lost no blood until the dressing had been removed two hours subsequently, Sept. 20, 1861, when he was conveyed to the hospital for treatment. On careful examination, the *brachial artery* was found wounded; without further delay an incision was made as for ligature of the artery, and the vessel secured above and below the wound, and the portion between the two wounds cut out. The venæ comites were also tied because they were wounded. With the exception of considerable œdema of the hand, forearm, and arm, which was controlled by bandages, the case progressed well. On Oct. 16, the patient was returned to duty, entirely well.[1]

In this case, the first or proximal ligature having been applied, the wound was carefully sponged, and red blood was distinctly seen jetting out of the mouth of the vessel from below, and that with considerable force, showing that the application of a ligature to the artery above the wound only would have been an insufficient and an incomplete operation. The arterial wound consisted of a gash which extended about half way across the artery, in a nearly transverse direction, and was situated about one inch below the origin of the artery. The weapon penetrated the limb in an oblique direction. The incision of the skin was about one inch long. On loosening the extemporized tourniquet, the hemorrhage did not recur; the wound was filled with coagulated blood; but it was found that there was no radial, nor ulnar, nor brachial pulse. The nature of the injury, therefore, could not be mistaken. But the ocular demonstration of regurgitating distal hemorrhage was, perhaps, the most interesting part of the case.

The history just related affords a capital illustration of what the treatment should be in cases where the main artery of an extremity is opened by an incised wound, namely, the arrest of hemorrhage, without any delay, by applying digital compression in the wound, or a tourniquet, or an elastic ligature above and below the wound temporarily, that is, until surgical aid can be obtained, and the artery tied properly above and below the gash in its coats. In the following example, although the compression was continued for eighteen days, the operation for applying ligatures had to be performed in order to obtain a cure:—

[1] Med. and Surg. Hist. of the War, Second Surg. Vol., p. 436.

A man, aged 36, accidentally stabbed himself with a pocket-knife toward the inner side and a little below the middle of the left thigh. There was a profuse escape of arterial blood, and he fainted. He was treated by compression for eighteen days, and brought to hospital on March 8. There was found some swelling surrounding an aperture in the skin an inch long, rounded in form, and situated as above stated. The tumor was hard, and did not pulsate. On the 12th, sharp hemorrhage suddenly occurred to the extent of an ounce or two. On the 16th, a pulsating tumor having formed at the seat of injury during the past two days, the artery was cut down upon by enlarging the wound, and tied, under chloroform. A large quantity of firmly laminated fibrin was turned out. The artery was compressed on the pubis by a finger during the operation. But little blood was lost, and recovery, though somewhat tardy, followed.[1]

One or two additional examples, briefly narrated, will impart more information concerning the treatment of this most formidable lesion of the femoral artery than a lengthy disquisition:—

Private George Hastings, Co. K, 37th Infantry, was admitted to hospital July 30, 1868, having been accidentally stabbed the same day, in the upper part of the thigh, with a long, narrow, exceedingly sharp hunting-knife, which, passing by the superficial *femoral artery*, partially divided the *profunda femoris* below the origin of the external circumflex. The hemorrhage was excessive. Some few moments only elapsed after the accident before complete syncope ensued. Pressure on the common femoral arrested the hemorrhage, but the prostration was so extreme as to prohibit operative interference at the time, and stimulants and nutriments were administered. At 10 o'clock P. M., hemorrhage again occurring, now from the lower or distal extremity of the artery, the wound was enlarged and the arteria profunda secured with ligatures above and below the lesion. The patient was kept for several days under the influence of morphia. Slight pressure continued on the common femoral, although not sufficient at any time to greatly impede the circulation in the limb. At no time after the operation was the circulation arrested. On the nineteenth day the upper ligature was removed, but the lower one did not come away until the thirty-fourth day. The patient recovered completely, and was returned to duty in the following October, between two and three months after the casualty.[2]

The following case, in which the employment of compression to temporarily restrain the first bleeding from an incised wound of the femoral artery, appears to have been neglected, has peculiar interest in this connection:—

A man, aged 53, was admitted to hospital on November 11, pulseless and faint from the loss of blood. There was a small wound, two inches below Poupart's ligament, in his left thigh, over the *femoral artery*, caused by a knife that had accidentally slipped. The bleeding, which evidently had been great, had ceased. He was placed in bed; and, as reaction came on, a pulsating swelling was revealed beneath the wound. Nov. 14—Tumor larger, and pulsation more marked. The tumor was laid open with a view to ligature the artery above and below the aperture in it. A large, gaping wound was found in the femoral artery. Much difficulty was experienced in applying the proximal ligature, on account of a large branch given off from the artery beneath the wound, which proved to be the profunda. After applying the proximal and distal ligatures and letting up the pressure, a fierce gush of blood from regurgitation through the profunda followed. This artery also was tied, and the hemorrhage ceased. The patient sank gradually, and died on the 21st, from exhaustion due to the loss of blood.[3]

The observations on punctured wounds of the femoral artery, and their treatment, at page 123, should also be consulted in this connection.

Incised wounds of the *popliteal artery* are not frequent occurrences; still, Deschamps has related a case:—

Etienne Repasses, a servant, aged 41, was admitted to hospital, on May 9, for a stab in the ham, inflicted with the point of a sabre, which completely divided the pop-

[1] British Medical Journal, August 3, 1872, p. 126.
[2] Circular No. 3, S. G. O., p. 242.
[3] British Medical Journal, Feb. 13, 1875, p. 211.

liteal artery. A traumatic aneurism formed. On June 20, it was laid freely open by an incision about six inches in length, all the clots were removed, the cavity was thoroughly cleansed, and a ligature was tied around each end of the severed artery about four lines from its extremity. A deep abscess in the leg ensued, which emptied itself into the wound. The patient died on the thirty-eighth day after the operation, apparently from pyæmia.[1] The result could have been no worse if the femoral artery had been tied on the plan of Hunter, or even if amputation had been performed.

In the following instance, Hunter's operation was performed: Private David Jones, Company E, 4th Infantry, was wounded at Fort Sully, on March 7, 1866, by a soldier who made a thrust with a large bread-knife, which entered the thigh transversely, about three inches above the inner condyle of the femur, and, passing almost through, severed the popliteal artery, vein, and nerve. The hemorrhage was controlled by compression, and it was then deemed best not to open the wound and attempt to ligate the artery therein. On the fourth day, some arterial hemorrhage occurring, it was thought unsafe to delay, and the femoral was tied at the middle third. There had been no warmth nor circulation below the wound since the injury, and at the time of the operation there were strong indications of gangrene. The patient died on the seventh day after the operation, March 16.[2]

Although the cause of death is not expressly stated in this case, still I think that it may fairly be taken by implication to have been traumatic gangrene. In many cases belonging to this category, where gangrene is likely to ensue, it will be advisable to amputate at the outset—that is, to perform primary amputation. No one plan of treatment can be prescribed which will suit all, or even the majority of cases, when the popliteal artery has been opened by an incised wound. In some cases it will be advisable for the surgeon to expose the artery, and ligature it above and below the seat of injury; in others, to perform Hunter's operation; and in still others, to amputate the limb. Each case must be judged by itself, and that procedure selected which appears most likely to save the patient's life. The occurrence of gangrene, however, always necessitates immediate amputation in these cases.

Incised wounds of the *tibial arteries* should, generally, be treated on the same plan as incised wounds of the femoral and brachial arteries, just described. The hemorrhage should be restrained by compression until the injured vessel can be laid bare and tied above and below the cut in its walls. Leisrinck has made, in a case of incised wound involving the anterior tibial artery, a fortunate application of the elastic compression of Esmarch. A man having been wounded in the leg with the point of a knife, there rose up in the course of the anterior tibial artery a bluish-colored and pulsating swelling, of the size of a fist. By employing elastic compression (see pp. 74–79), Leisrinck was enabled to readily apply to this traumatic aneurism the ancient method of operating; namely, to freely lay open the sac, completely evacuate its contents, and find and tie the artery above and below its open mouth.[3]

No doubt, in many cases where the *tibial arteries* are wounded, the elastic ligature may, with great advantage, be applied to the leg, both above and below the wound, so as to effectually control the circulation while the injured artery is being ligated on the "old plan." Boyer has forcibly illustrated the great superiority of the "old plan" of treatment in such cases:—

A young man received an incised wound involving the posterior tibial artery in the lower part of his leg, near the internal ankle. In some additional cases, the malleolar and tarsal arteries which run over the foot were likewise divided. These patients all died; they might have been saved, if, instead of stuffing the wounds with styptics and lint, the surgeon had cut down upon the arteries and tied them above and below.[4]

[1] Observations on Aneurism, Sydenham Society's edition, p. 410.
[2] Circular No. 3, S. G. O., pp. 241, 242.
[3] Nouveau Dictionnaire de Méd. et de Chirurg. pratiques, t. xix. Paris, 1874.
[4] Op. cit., vol. i. p. 132, Am. ed.

In the following example the *dorsal artery of the foot* was ligatured on this plan with a good result:—

Private James Lasby, Co. G, 23d Infantry, aged 33, while chopping wood at Fort Colville, on December 15, 1868, cut his right foot with a sharp axe. The flexor tendons of the foot, the dorsalis pedis artery, and the metatarsal bone of the great toe were divided, causing a gaping wound four inches in length. He was admitted to the post hospital, where the dorsalis pedis artery was ligated, and the wound closed by interrupted suture. The wound failed to unite by first intention, and, on Dec. 20, the ligature was removed. The patient was returned to duty in March, 1869.[1]

Distal ligatures must be applied to wounded arteries in the foot and leg, as in the hand and arm, in order to guard against the regurgitating hemorrhage which, in their absence, would result from the remarkably free inosculations of the terminal branches with each other by means of the plantar arches, etc., in the one case, and of the palmar arches, etc., in the other. Hemorrhage from incised wounds of the foot, ankle, and leg, when the wound is recent and the parts are sound, will give the surgeon but little trouble provided he treats it on the orthodox plan of bringing the bleeding point distinctly into view, applying a ligature on each side of it, and dividing the artery midway between the ligatures, so that the ends may retract.

During the late civil war, three hundred and fifty-seven cases of incised and punctured wounds of the upper extremities were reported. There were four deaths: two from neglected arterial bleeding, one from gangrene, and one from a fever long after the wound had healed.[2] Incised wounds of the *brachial* artery have already been discussed at sufficient length. The examples of *punctured* wounds of the brachial artery and the remarks thereon, given at page 120, should also be examined in this connection.

Incised wounds of the shoulder are sometimes attended by a tremendous hemorrhage from lesion of some branch of the axillary or subclavian artery, as happened in the following instance, where the *posterior circumflex* artery was opened:—

Private Thomas Quigley, Co. G, 17th Infantry, aged 21, received, at Sulphur Springs, Texas, on December 24, 1868, an incised wound of the left shoulder, eight inches in length, from the shoulder downward. He was admitted to the post hospital; he had fainted from the loss of blood, and his pulse was almost imperceptible. The wound was explored, and the posterior circumflex artery, which was found injured and bleeding, was securely tied; the edges of the wound were brought together and held by silk sutures and adhesive plaster. On December 31 the wound was healing rapidly. In February, 1869, the patient was returned to duty.[3] This case usefully illustrates the plan of treatment which should be carried out in all cases of hemorrhage from incised wounds of the shoulder and arm where the lesser arteries are involved. The wound must be explored, and the bleeding vessel must be brought into plain view, and securely tied. In this way the very best possible results are obtained. But stuffing such wounds with lint soaked in the persulphate or perchloride of iron has often been attended with disastrous consequences.

How should incised wounds of the *radial*, *ulnar*, and *interosseous* arteries be treated? On this point the brief presentation of a few cases will give the requisite information in a convenient way.

When the radial artery is completely divided, properly adjusted compression at the wound will not unfrequently stop the bleeding permanently, as it did in a case reported by Dr. Franz in the Medical and Surgical History of the War.[4] But this is not always, nor even generally, the best practice, and

[1] Circular No. 3, S. G. O., p. 243.
[2] Med. and Surg. Hist., Second Surg. Vol., pp. 436, 437.
[3] Circular No. 3, S. G. O., p. 243.
[4] Second Surg. Vol., p. 436.

when the wound is inflamed or much swollen, it cannot be employed. Much preferable to it for general use is ligation according to the ancient method, as was practised in the next two examples:—

A soldier, aged 24, received, September 22, 1868, an incised wound on the dorsal surface of his right hand, severing the radial artery. He was taken to hospital, where both extremities of the artery were ligated. On September 30 the patient was doing well; in October he was returned to duty.[1]

A cavalry soldier at West Point severed the radial artery by striking his fist through a window-pane May 31, 1868. The wound was enlarged by incision, and both ends of the artery were tied by Dr. E. J. Marsh. Considerable swelling followed; the wound, however, healed with but slight suppuration. On June 9 the ligatures were removed; on the 18th the patient was returned to duty.[2]

The following case, in which the ancient method of ligation had finally to be practised for an incised wound of the ulnar artery, will serve to show the comparative value of several different plans of treating the consequences of this wound:—

A zinc-plate worker, aged 29, was admitted to St. George's Hospital March 6, under care of Mr. Pick. Twelve days before, a chisel slipped and entered his left wrist over the ulnar artery. Profuse hemorrhage followed; it was controlled at first by a ligature tied tightly round the arm, and subsequently by direct pressure over the wound, which was maintained for two or three days, the wound, on its removal, being found healed. In the course of a few days, however, a swelling appeared, which, on admission to hospital, was found to be oval in shape, of the size of a walnut, and situated on the wrist in the course of the ulnar artery. It was surmounted by a cicatrix. Pulsation and bruit were marked. The forearm was kept forcibly flexed upon the arm for twenty-one hours, without benefit. Two horse-shoe tourniquets were next applied, one on the brachial, the other on the ulnar artery, and were kept on as long as the patient would bear them, and until the limb was very œdematous, but without success. On April 15, galvano-puncture was applied. On the second day afterward the sac burst, and much bleeding ensued. The sac was then laid open from top to bottom, and a few clots, with some decolorized fibrin, turned out. In the posterior part of the sac the upper and lower orifices were seen. The vessel was then tied above and below, and divided between the two ligatures. The man made a good recovery.[3]

Had the last operation been performed at the outset, much time, much expense, much trouble, and much suffering would have been saved to patient and surgeon. Let me here say, also, that hemorrhage from incised wounds of the radial, ulnar, and interosseous arteries, or their branches, when the wound is recent and the parts are sound, will give the surgeon but little trouble, provided he treats it on the orthodox plan of bringing the bleeding orifice clearly into view, applying a ligature on each side of it, and dividing the artery midway between the two ligatures, so that the ends may freely retract. But if the surgeon rely on compression and styptics, in such cases, he may cause for himself a great deal of trouble, and for his patient a great deal of suffering, which could readily have been avoided by ligaturing the wounded vessels according to the method just described. In such cases, too, distal ligatures are indispensable in order to prevent the regurgitant bleeding which, in their absence, would ensue from the remarkably free inosculations that exist between the terminal branches by means of the palmar arches, etc.

Incised wounds involving the *palmar arches* are not unfrequently met with. They are caused by the sharp-edged tools of industry; also by grasping with the hands, in self-defence, the razors, knives, and daggers with which assaults are made. These wounds, when treated at the outset on the orthodox plan

[1] Circular No. 3, S. G. O., p. 237. [2] Ibid., p. 237.
[3] British Medical Journal, June 1, 1872, p. 582.

described above, give but little trouble. But, as the late Dr. Otis very justly remarks: "The subjects of such injuries are very unfortunate if they have not the services of a surgeon possessed of the requisite skill and courage to thoroughly explore the wound at the outset."[1] I do not say that such cuts never get well under the use of compresses and bandages; I do say, however, that compression often fails to check the bleeding permanently, and that I have seen several instances of such a failure, in some of which the patients were blanched or exsanguinated, and exhausted, from the frequently recurring hemorrhages. Professors Gross and Agnew advise that the general rule for the treatment of wounded arteries should not be deviated from here; and that in recent punctured or incised wounds of the palmar arches, the wound should be enlarged and both ends of the bleeding vessel tied. But the neglected cases present the real difficulties; and in these, compression, cauterization, acupressure, ligation of the radial or ulnar artery, or both, and ligation of the brachial artery, have all been employed with reported successes and failures. Concerning the neglected cases, Professor Von Pitha observes: "I saw several cases of exceedingly rebellious bleeding from cuts and stabs of the palm; two of these were brought to me after numerous ineffectual attempts to stop the bleeding, in a profoundly anæmic condition; yet I was never forced to practise ligation, as the bleeding ceased, on removing the coagula, completely and permanently. . . . . The first thing to be done in such cases is to freely expose the bleeding vessel by enlarging the wound, and to boldly clear away all coagula. The irritation caused by the sponge and by the admission of cool air frequently induces the gaping arterial wound to retract. The wound should not be immediately closed, but should be kept under close observation for some time."[2] Many other surgeons, including the author, have likewise seen, in cases of recurring hemorrhage from wounds of the palm, the bleeding cease completely and permanently on laying bare the open mouth of the bleeding vessel, by enlarging the wound, completing the division of the artery in cases where it was incompletely divided, and at the same time removing all coagula and thoroughly cleansing the wound. The ends of the severed artery, which projected at first from the surface of section, have many times been seen to retract, contract, and become completely closed, so that all future hemorrhage was effectually restrained. The most important points to be considered in treating hemorrhage from wounds of the palm are: (1) To distinctly bring into view the mouth or mouths of the bleeding artery, by enlarging the wound; (2) to complete the division of the artery whenever it is found to be incompletely divided; (3) to remove all clots and foreign substances from the wound, and apply pressure to the ends of the severed artery by means of a finger placed in the wound; and (4) if the ends of the artery do not retract, contract, and become completely occluded with a supplemental internal coagulum, to place a ligature of carbolized catgut, securely, on each of the ends. In all cases, whether they be quite recent, or old and neglected, or badly treated, the bleeding artery must be sought for and found in the wounded palm. (For further information on this and other important points, examine the cases and the discussion of punctured wounds of the palmar arches on p. 121.) The objection that a search for the wounded artery may necessitate more or less mutilation of the palm should not be allowed to have much weight against the possibility of failure, as well as the danger, which, in such cases, attends upon the deligation of the arterial trunks in the forearm and arm.

Incised wounds involving the lesser arteries of the head and face should

[1] Med. and Surg. Hist. of the War of the Rebellion, Second Surg. Vol., p. 437.
[2] Ibid., p. 437, foot note.

be treated by removing all the coagula and exposing the aperture whence the blood issues distinctly to view, by completing the division of the artery whenever it is not complete, and by applying pressure to the ends of the divided artery with a finger in the wound. The success of this proceeding can be considerably aided by simultaneously compressing the trunk of the common carotid artery against the transverse processes of the vertebræ, on the same side as the wound (see Fig. 342, p. 68), with the thumb of the other hand. If in a short time the bleeding is not stanched by these proceedings, a ligature must be put on each end of the wounded artery. In cases where the ligatures, both proximal and distal, have been applied without previously dividing the artery, the artery should be divided midway between the ligatures, so that retraction of the ends may take place.

The hemorrhage from incised wounds of the neck involving the occipital, vertebral, or superior thyroid artery, should be treated on the same general plan as the hemorrhage from incised wounds of the carotids; the surgeon should explore the wound with an index finger, find the aperture in the vessel, from which he will feel the blood issue with each pulsation, place the tip of his finger on this aperture, enlarge the wound if necessary, apply a ligature on each side of the aperture, and finish by dividing the artery midway between the two ligatures. In the following example, the superior thyroid artery was severed by an incised wound, both ends were ligated, and the bleeding did not recur:—

Private J. H., Co. K, 1st Infantry, aged 27, cut his throat with a razor November 3, 1866. The larynx was opened, and the superior thyroid artery was completely divided. When admitted to the post hospital he was nearly pulseless. Both ends of the divided artery were immediately ligated. The patient did very well, and seemed to improve until the evening of Nov. 5, when he had a choking fit, and died in a few minutes from asphyxia.[1]

The hemorrhage from incised wounds involving the arteries of other regions, for instance, the armpit, the groin, the thigh, etc., should be controlled in the same way by the surgeon. He should explore the wound with a finger, feel for the orifice in the wounded vessel from which a stream of blood issues in jets, cover it with the end of his finger, and keep it so covered until he can enlarge the wound, and tie the artery on each side of the aperture. He should also divide the artery midway between the two ligatures, unless this has already been done. Concerning the intercostal, internal mammary, internal epigastric, gluteal, vertebral, and many other different arteries, the reader may consult what has been said concerning them in describing the treatment of punctured wounds of arteries, pp. 117–135.

The *ligatures* to be applied should always be *antiseptic*, and of *animal origin*. Both ends should be cut off near the knot; incised wounds should, as a rule, be closed immediately with interrupted sutures or with strips of adhesive plaster. In all wounds involving arteries, antiseptic dressings only should be applied.

*Transfusion* is likely to prove useful in many cases of anæmic exhaustion, when it is due to excessive loss of blood from the incised wounds of arteries, and the possible utility of this procedure should not be overlooked in the after-treatment of such cases.

## Wounds of Veins.

Complaints are justly made that this topic receives scant notice in some works on surgery, although the wounds of veins are of frequent occurrence,

[1] Circular No. 3, S. G. O., p. 236.

and although those which involve the large venous trunks must be classed among the most fatal of all accidents. Almost every conceivable wound is attended with the lesion of some vein, however small or large it may be; and wounds of the internal jugular, subclavian, and axillary veins, or of the common iliac, external iliac, and internal iliac veins, are quite as fatal as wounds of the carotid, the subclavian, the axillary, or the iliac arteries, and perhaps even more so. In estimating the gravity of such lesions, it should also be considered that the walls of veins are thin, and their contractile power very feeble; that their capacity, always great, increases with age, so that, when they are opened by wounds, the loss of blood will be greater in the old and debilitated than in the young and strong, while the conveying capacity of the arteries is correspondingly diminished.

The veins are wounded, not only very often, but in various ways: homicidally, suicidally, accidentally, in surgical operations, and in war.

The principal sources of danger in venous wounds are:—

1. Primary hemorrhage.
2. Secondary hemorrhage.
3. Septicæmia.
4. Traumatic phlebitis.
5. The entrance of air into the circulation.

Symptoms of Venous Wounds.—A vein is known to be wounded when dark (or so-called venous) blood flows in a rapid and uniform stream from the seat of injury. Sometimes it will be prudent not to decide hastily, especially in cases where the blood issues from a deep wound. Generally, however, the question may easily be determined; but in cases of doubt we may get valuable aid by compressing the main vascular trunks on the cardiac side of the wound. If the hemorrhage be restrained by so doing, we are assured that it is arterial; but if it be increased, we are almost equally assured that it is venous. Still, it should be remembered that in the extremities the blood which flows from the distal aperture of a wounded artery has a dark color, and flows in a steady stream.

The wounds of small veins are less serious than similar injuries of small arteries, because the blood-pressure is less strong, the blood-stream is less swift and powerful, the heart's contractions are less felt, and, consequently, there is less risk from hemorrhage in the former than in the latter. Dr. Otis, the distinguished historiographer of our civil war, observes: "Hemorrhage of consequence from the lesser veins must be a rare event. In a single instance in the reports, attention is directed to bleeding from a gluteal vein."[1] The small veins, when divided, close spontaneously in a few seconds, or their closure may be hastened by elevating the wounded part, or by applying cold or other hæmostatics. When veins no larger than those of the subcutaneous tissue bleed persistently, it is usually because there is some impediment to the flow of blood toward the heart. In a case of this sort which I saw at the battle of Ball's Bluff, the impediment was caused by an extemporized tourniquet, which had been placed around the wounded arm of a soldier by a comrade; on removing the constriction and applying a roller to the arm, the bleeding ceased. In prolapsed hemorrhoids, also, the grip of the sphincter ani often causes a large loss of blood in a few minutes, which can be promptly suppressed by dilating the muscle and returning the tumors into the rectum. So, too, free bleeding from branches of the portal vein is sometimes caused by certain morbid conditions of the liver which obstruct the flow of blood from that vein; and here the causal indication for treatment is to remove

[1] Medical and Surgical History, etc., Second Surgical Volume, p. 338.

the hepatic disorder. The hemorrhage from small veins, when wounded, seldom gives trouble, and can always be controlled by removing the obstruction which causes it. But when large venous trunks, as, for instance, the innominate, the internal jugular, the subclavian, or the axillary, are divided, death follows in a few minutes from the loss of blood, as the cases to be related will abundantly show.

The flow of blood from wounded veins in the neck is remarkably affected by the respiratory movements. During inspiration, when the walls of the thorax are expanded, and when no obstacle is offered to the passage of the blood toward the right side of the heart, the wounded vein remains shrunken or partially collapsed, without shedding a drop of blood; but in expiration, when the thorax becomes contracted, when the great venous channels at the root of the neck become compressed by the lessened diameter of the thorax, and there is a momentary pause in the downward flow of the stream, the blood wells up in the breach as from a fountain.

The wounds of deep veins, even those that are not large, always have a grave importance when the injured vessels are so situated that the blood can flow from their open mouths into one of the great cavities of the body, as, for instance, the cavity of the abdomen, that of the thorax, or that of the cranium; for in this way a fatal hemorrhage may ensue—a hemorrhage, too, over which art has but little control.

The wounds of veins, like the wounds of arteries, may, for purposes of study and description, be advantageously classified as follows:—

1. Incised and punctured wounds.
2. Contused wounds.
3. Lacerated wounds and ruptures.
4. Gunshot wounds.

In incised, in lacerated, and in gunshot wounds, the vessel, as a tube, may be either partially or completely divided. In punctured wounds the division is, of course, always incomplete; and, in contused wounds the vein is not, as a rule, opened until the bruised portion separates as a slough.

When a vein is completely divided, its ends contract, although somewhat less than the ends of a severed artery; they also retract into the sheath. The natural hæmostasis is promoted by these movements, and by the formation of a coagulum around the orifice. But these processes are slow in their operation, very feeble, and practically insufficient, at least in the case of large veins. When, therefore, deep veins of large size are divided and cannot be treated, a fatal result rapidly ensues from the hemorrhage.

When veins of some magnitude are partially divided, the bleeding often gives much trouble. It does not, however, when the injured vessel is superficial, and is located in one of the extremities, because by elevating the limb, and by applying a compress over the wounded part with carefully adjusted pressure by means of adhesive strips or a roller, we can almost always suppress the bleeding, and then, in three or four days, union by adhesion may fairly be expected.

After the hemorrhage is controlled, the wounds of veins, as a rule, heal very quickly. They often unite by the first intention, and heal so perfectly as not to leave any appearance of a scar. The repair of wounds made in veins differs in no essential respect from the same process in arteries. The blood pressure or tension of the circulation in wounded veins, however, is not strong enough to separate the adhesion of the lips or margins while union by the first intention is taking place. Hence, the wounds of veins in one respect heal very differently from the wounds of arteries. While the tubes of the latter are almost invariably obliterated in the human subject, even after punctured wounds, the wounded tunics of a vein can readily be repaired

without at all diminishing its calibre. We all know how seldom the canal of a vein has been obliterated by the operation of venesection; and the same disposition to maintain the permeability and lumen of its canal is witnessed after most wounds in which a vein is partially divided. In a case recorded by Guthrie, where the internal jugular was cut into, the cure at the end of eight days was found to be so complete, that the vessel was not only pervious, but without a mark to indicate where the wound had been.

The following example shows how injured veins heal when ligatured:—

Professor Langenbeck, while removing an epithelial cancer, wounded the internal jugular vein, and tied the cardiac end only, there being no hemorrhage from the distal end. The common carotid artery being involved in the tumor was tied with two threads and divided. When operated on, the man had bronchitis, from which he died on the twelfth day. A *necroscopy* showed the vein completely healed as if by the first intention, without the slightest trace of redness, thickening of its walls, or formation of a clot.

Travers was the first to show that veins, when ligatured or divided, united without any adhesive inflammation. The fact is, the venous tunics when wounded heal more perfectly than almost any other structures in the whole body.

The hemorrhage from wounded veins should be restrained, (1) by raising up or elevating the wounded part; (2) by carefully applying pressure by means of well-adjusted compresses, with adhesive strips or bandages; (3) when these prove inadequate, by applying ligatures, without hesitation, above and below the seat of injury. The ligatures should consist of carbolized catgut, and antiseptic dressings should be applied to the wound. All the measures for restraining hemorrhage from wounded arteries are applicable to wounded veins; and the ligation of veins is as free from special danger as the ligation of arteries.

To ligature a large vein in its continuity, the surgeon should pass around it the blunt end of an eyed probe, or a Mott's aneurism needle, armed with a thread of carbolized catgut, carefully separating the vein from the accompanying artery and nerve, but to no greater extent than is absolutely necessary.

Incised and Punctured Wounds of Veins.—In every act of venesection a punctured or an incised wound of a vein is made. In most amputations the section of large veins is a matter of necessity. In many of the subcutaneous operations for tenotomy or myotomy, the lesser veins are punctured or divided. Sometimes, too, the great venous channels are accidentally opened by surgeons. Wounds of veins thus made generally heal quickly and kindly; and we may well say, therefore, that the incised are the least harmful of all the venous wounds. The incised and punctured forms of venous wounds often occur in the common accidents of life; they are, likewise, frequently made by persons in attempts to destroy their own lives; they are, too, not unfrequently inflicted with the weapons of war and in warfare; and finally, they are sometimes inflicted by persons while committing, or attempting to commit, the crime of murder, and hence they are important in a medico-legal point of view.

The following example comes under the last named-head:—

Mary Dean, a young mulatto girl, was gashed in the left side of her neck, about 10 P. M., June 13, 1880, by Augustus D. Leighton, a jealous lover, with a razor, during an interview, while standing in the street near the basement door of her home. Her aunt, who was looking on from a window above, testified: "I saw him make a sweep with his hand, and Mary vanished into the basement; it was all over in a moment; I found her in the basement, on the floor, all covered with blood, and dead." Another eye-

witness, testified: "Leighton gave a sweep with his right hand; Mary staggered into the basement, and pointing three times up towards her apartments, fell over and died, without saying a word." All the eye-witnesses testified that the blood ran down from her neck in a great stream. At the autopsy, an incised wound, five inches in length and two inches in depth, severing the internal jugular vein but not the carotid artery, was found on the left side of the neck; and there had evidently been but a single stroke of the razor.

It is somewhat remarkable, that, although the internal jugular vein has not unfrequently been opened in incised wounds with a fatal result from the loss of blood, S. W. Gross, on diligent search, could find only four cases on record. This circumstance affords good cause for reporting the above case with some minuteness of detail. Death ensued from the loss of blood in one, or at the utmost, two minutes. Incised wounds dividing the internal jugular vein that have size enough to allow the blood to escape externally without any hindrance, prove fatal quite as speedily as similar wounds of the common carotid artery, if not more so. In accounting for the extreme rapidity with which death ensues, in such cases, the enormous capacity of the internal jugular vein for discharging blood, and its freedom from valves, as well as the anatomical relation which it bears to the great sinuses of the dura mater which empty directly into it, must be considered. Thus, the hemorrhage occurs in a great stream drawn directly from the cranial cavity, whereby cerebral anæmia of a fatal character is directly produced with the greatest possible celerity.

The following example, as far as it goes, confirms these views:—

M. Vallée saw a soldier who had been stabbed in the neck, the right jugular vein being almost completely divided. The edges of the wound were retracted, and the vein was empty. Death was almost instantaneous.[1] This example, like the last, vividly illustrates the destructive power of the primary bleeding in such instances.

But, in cases where the internal jugular vein is gashed, if the hemorrhage be restrained by timely compression until the vein can be ligatured above and below the lesion, the patient may be saved, as is shown by the result in the following instance:—

Mr. John Woodman[2] records the case of a woman whose throat was cut with a razor. A longitudinal wound was found in the left internal jugular vein, a wound therefore at right angles to that in the skin. Owing to the hemorrhage necessitating constant compression, much difficulty was experienced in ligaturing the vein, but it was finally tied above and below the wound. The bleeding came from the distal part of the vessel. The result was successful.

A case is reported in the Medical and Surgical History of our civil war which admirably illustrates the same point:—

Private William McDonald, Co. F, 51st New York Volunteers, received a gunshot fracture of the lower jaw, March 14, 1862. The missile lodged behind the common carotid artery and the internal jugular vein. In cutting down over the ball, in order to extract it, on January 5, 1863, the vein was accidentally wounded. The hemorrhage, however, was inconsiderable, being controlled by pressure, the danger of cutting the vein, and the probability of the accident, having been anticipated and provided for. The ball was extracted with some difficulty. A double ligature was passed around the vein, so as to secure it above and below the aperture. The wound was drawn together by interrupted sutures and adhesive straps. It healed kindly, the ligatures coming away on the ninth day after the operation.[3]

[1] Gaz. Médicale, 1837, p. 267; and American Journal of the Medical Sciences, January, 1867, p. 37.
[2] British Medical Journal, October 18, 1873.
[3] Medical and Surgical History, etc., First Surgical Volume, p. 397.

Thus it is clearly shown what should be done when the internal jugular vein is gashed, whether accidentally by a surgeon in operating on the surrounding parts, or designedly by an assassin; the bleeding must be restrained by compressing the wound, with the fingers if possible, until the vessel is securely tied on each side of the aperture in its walls.

The large veins of the extremities when cut open, whether by accident or by design, should be treated on the same plan if compression is inadequate to suppress the bleeding, as was done by the late Dr. George McClellan in the following instance:—

In extirpating from a gentleman's groin a large fibrous tumor, which was wedged into the external crural ring and the femoral canal, and while detaching it from the femoral vein, he found the saphena interna involved in the substance of the tumor, just as it emptied into the trunk vein. He was obliged to divide it there; and afterward failing to restrain a tremendous gush of black blood by pressure, he pursed up the orifice by a spring tenaculum and Liston's forceps, and had a fine silk thread tied around the margin. This succeeded perfectly in restraining the hemorrhage, and was followed by no inconvenience. He remarks that it was the largest venous orifice he ever saw ligatured, and that it was large enough to admit one of his ring-fingers.[1]

*Punctured wounds* are sometimes accidentally made by surgeons in the walls of large veins, with the points of their scalpels, while removing tumors. In a case which I saw some years ago, where the internal jugular was punctured in this manner while dissecting out a deep-seated tumor of the neck, the margins of the puncture were drawn together and raised up by a Liston's forceps, and a ligature was tied around them on the side of the vessel—that is, a lateral ligature was applied. This proceeding was successful. Nevertheless, it should not be imitated, because of the great risk of secondary hemorrhage which attends it. For example, it is reported on the authority of Nélaton, that Roux tried lateral ligation of the internal jugular in three cases, but that all of them proved fatal from secondary hemorrhage about the sixteenth day.[2] In such cases the primary bleeding should be controlled if possible by compression, and if, after a fair trial, this is found inadequate, the wounded vein must be ligatured above and below the puncture.

The Army Medical Museum contains a specimen of punctured wound of a large vein. It consists of "a wet preparation of the left femoral vein pierced by a darning-needle. Private B. A., 'A,' 5th Iowa, 40; a conoidal ball passed through Scarpa's triangle without directly injuring the bloodvessels, Vicksburg, 19th May; admitted to hospital with wound in a sloughing condition, Memphis, 27th; hemorrhage checked by compression, 31st of May; wound opened and needle extracted from the sheath at 2 P. M.; artery ligated for secondary hemorrhage at 8 P. M.; died at 11 P. M., 1st June, 1863."[3]

The veins in the extremities are often punctured by the fragments in cases where the long bones are fractured. In such cases, considerable tumefactions not unfrequently arise from the extravasations of venous blood, but, as a rule, they speedily subside under the combined influence of quietude and moderate compression. The large veins in the neck, etc., are sometimes pierced in a fatal manner, in gunshot wounds, by the splinters of bone that are broken off by musket-balls. For instance, Stromeyer, in 1849, had a case of gunshot fracture of the lower jaw, in which fragments of the bone were driven deep into the throat. The man "died suddenly on the fourth day, in the presence of his attending physician, a thick stream of dark blood issuing from his

[1] Principles and Practice of Surgery, pp. 194, 195. Foot-note.
[2] American Journal of the Medical Sciences, April, 1867, p. 327.
[3] See Catalogue, A. M. M., p. 472, Spec. 2020.

mouth." The *autopsy* showed an opening in the internal jugular vein, made by a splinter of bone, which still remained in it.[1] As soon as the mechanical obstacle became loosened by suppuration, hemorrhage ensued.

Large veins are sometimes punctured by the minute bird-shot or squirrel-shot of sportsmen, as happened in a case already related on page 115, that occurred in the practice of Professor Gross, where the right internal jugular vein was penetrated by a squirrel-shot, and the venous wound healed in a noteworthy manner, without the aid of a blood-clot or the occurrence of inflammation—healed in fact by the first intention—and the shot itself became encysted, by the same process, in the wall of the vein at a point opposite to the place of entrance. The patient died on the fourteenth day after the accident, from protracted epileptic convulsions, and the autopsy revealed what has just been described.[2] The subclavian artery also was punctured. The case is of some importance, because it shows the way in which venous wounds may heal, and that the venous tunics may sustain a severe injury without resenting it.

A large vein is sometimes accidentally punctured or transfixed by an artery-needle in performing the Hunterian operation for aneurism. Two fatal examples of this sort, in which the internal jugular was pierced through and through, are presented by Dr. S. W. Gross in a most excellent article on "Wounds of the Internal Jugular Vein."[3] The transfixion of the vein escaped notice in both instances, and the ligature passing through the vein acted as a seton after the operation. Hence, there ensued ulcerative inflammation in the vein-wall, and the train of phenomena usually ascribed to diffuse or suppurative phlebitis, with death from pyæmia. Indeed, it would be hard to plan an experiment more likely to produce such results than the establishment of a seton in this manner in a large venous trunk extending across its channel. There are also on record some fatal cases in which the femoral vein was pierced in like manner, while operating on Hunter's plan for popliteal aneurism. It is, therefore, of great importance that this mishap should be avoided, and, in case it does occur, that it should immediately be detected. In such cases the ligature must be withdrawn, and reapplied at another point. The bleeding will generally cease on tightening the ligature, this cutting off the blood-supply that otherwise would go to the distal part of the limb, and flow back toward the heart through the punctured vein.

Contused Wounds of Veins.—The tunics of veins, like the tunics of arteries, are sometimes bruised by the impact of musket-balls and other missiles in gunshot wounds. When large arteries are contused in this manner, the accompanying veins, likewise, are often found to be contused. For example, in one of Mr. Guthrie's cases, already mentioned in the section on Contused Wounds of Arteries, the walls of the femoral vein were bruised by a musket-ball as well as the walls of the artery, and the canal of the vein was "filled by a coagulum, and impassable" at the bruised part. The case of P. Ryan, related in the same section, in which a bullet had grazed, but not opened, the sheath of the femoral vessels, and bruised the femoral artery, affords another illustration. "The vein, however, was not only also slightly contracted, but its internal surface was inflamed and filled with partially organized lymph, as far up as the entrance of the deep iliac vein, and downwards for about two inches from the wound. Its course was thus entirely sealed, but nothing like pus could be found in the femoral or iliac veins, nor in the system anywhere."[4]

[1] American Journal of the Medical Sciences, January, 1867, p. 39.
[2] Ibid., January, 1867, pp. 41, 42.
[3] Ibid., January, 1867, pp. 31, 32.
[4] Surgical History of the Crimean War, vol. ii. p. 343.

In both cases the inflammation was formative in character, and there resulted contraction of the bruised part of the vein, and obliteration of its canal.

But the contused wounds of veins which are caused by musket-balls and other like missiles, not unfrequently give rise to secondary hemorrhage. The bruised part of the vein separates as a slough, the canal of the injured vein is opened, and an effusion of blood into the wound, or a hemorrhage, takes place. The Army Medical Museum contains several specimens which illustrate this accident:—

One of them is "a wet preparation of a portion of the right internal jugular vein, after secondary hemorrhage from gunshot. The specimen shows the point of sloughing, and is occupied by a coagulum two inches below the orifice. Private S. W. S., 'B.,' 1st N. Y. Dragoons, 23; ball entered two inches below and to the right of the superior angle of the scapula, passed through the neck and fractured the inferior maxilla. Spottsylvania C. H., Va., 8th May; admitted to hospital, Alexandria, Va., 24th; secondary hemorrhage, arrested by persulphate of iron, 27th May, 1864; date of death not reported."[1]

Another illustration of this accident is "a wet preparation of the upper portion of the femoral vein, showing the point of sloughing after gunshot. The orifice is nearly opposite the mouth of the profunda." Private M. H., aged 21, was the patient. He was wounded and admitted to hospital April 1, 1863. Venous hemorrhage occurred on the 10th, 11th, and 13th; on the 15th he died. In both instances the loss of blood appears to have been the cause of death.[2]

The following case belongs to the same category:—

Private M. A. R., Co. E, 46th Ohio Vols., wounded at Dallas May 27 or 28, 1864; admitted to hospital on the 28th. A ball entered the right side of the face about the middle of the buccinator muscle, fractured the inferior maxilla, passed downward into the neck on the same side, and, lodging, could not be felt. May 30—He felt well; appetite and pulse good, but he could swallow liquid food only. He continued to do well until June 7 and 8, when he lost a great deal of blood from the wound, and became much reduced thereby. On the 27th there was some hemorrhage at seven A. M., which was arrested by compression. At nine o'clock he had a convulsion, and died. At the *autopsy*, the internal jugular vein was found opened for about four inches, and the tissues on the same or right side of the neck were infiltrated with pus. The missile had also fractured the transverse processes of the third and fourth cervical vertebræ, and had passed into the chest.

In this case the missile was deflected downward into the neck by striking the lower jaw. Thus, the internal jugular vein was grazed and bruised. Some ten or eleven days after the casualty, and when the slough separated, the internal jugular was opened, and profuse hemorrhage from the wound took place. The bleeding was suppressed, but after a time it recurred, and the man died, having syncopal convulsions (*convulsio syncopalis*) due to the loss of blood. Were it desirable, additional examples could readily be adduced.

*Treatment.*—The principal indications to be fulfilled in the management of contused wounds affecting veins are: (1) To prevent the occurrence of ulcerative phlebitis and secondary hemorrhage; (2) to prevent the absorption of septic matter and the occurrence of septicæmia or pyæmia. Both of these indications are best accomplished by the use of antiseptic dressings and thorough drainage in such wounds; for, in this way, the retention and putrefaction of purulent matter are avoided, and these two sources of danger are eliminated from the case. Should, however, secondary hemorrhage occur, it must be restrained without delay by compression (digital or otherwise) until the bleeding vein can be laid bare, and securely tied above and below the aperture in its walls with ligatures of carbolized catgut. In cases where

[1] Catalogue, A. M. M., p. 470, Specimen 2441.
[2] Ibid., p. 471, Specimen 1093

large venous trunks, such as the internal jugular, or the axillary, or the common femoral, are opened in this manner, promptitude in getting complete control of the hemorrhage is a matter of the first importance; and, therefore, no time should be lost in experimenting with the persulphate or the perchloride of iron, or other astringent substances.

Lacerated Wounds and Ruptures of Veins.—The walls of veins are much thinner and less strong than the walls of arteries; hence, the subcutaneous veins are much more liable to be ruptured by blows than the corresponding arteries. Contusions of the soft parts are very often attended with the laceration or rupture of underlying veins, giving rise to dark discolorations or ecchymoses, and, sometimes, to large sanguinolent collections, which remain liquid for a long time. These bloody tumefactions, or *hæmatomata*, should never be opened by the surgeon unless they suppurate, that is, terminate in abscess, or, having become very chronic, cause annoyance by their bulk. While they are still recent, time and the employment of stimulating lotions, in order to hasten absorption, constitute the proper method of cure.

Large veins are sometimes torn completely across in open lacerated wounds:—

A case of the kind occurred some years ago in the person of a gentleman, under the late Dr. George McClellan's care. "His right groin was caught by a large, blunt, iron hook, in a horse-mill, and he was dragged rapidly round the area by it, until a monstrous rent was torn across, just below Poupart's ligament, laying bare the femoral vessels and nerves. The artery was completely denuded, and the vein torn across. A prodigious venous hemorrhage ensued." The artery was taken up, although it did not bleed at the time. The hemorrhage from the vein was restrained by filling the wound with graduated compresses, and binding them down with a thick bandage. "The result was, that the enormous wound finally healed, and the gentleman eventually got well, although in the mean while the leg mortified and was amputated just below the knee."[1]

Dr. McClellan's remarks on this case are so pertinent that I will quote them: "Now it is an interesting point to decide whether the ligature around the main artery, which I supposed to be unnecessary and would have opposed, had I been consulted respecting it before the operation, was the cause of the mortification, or whether, as was inferred by some, it was not rather calculated to prevent that unfortunate occurrence. The latter class of my friends considered that the destruction of the great vein at the groin would have caused too great a congestion of venous blood in the parts below, unless the corresponding artery had also been obstructed by the ligature. But other veins, as well as arteries, might have become dilated in the meanwhile, as indeed they must have done to some extent, because the vitality of the whole knee and parts above was preserved."

The recovery of the patient, in this case, shows that the ligation of the artery was good practice; without such a ligation of the femoral artery, the bleeding from the severed femoral vein would not have been controlled by compression applied in the wound. The restraining effect of tying the femoral artery upon hemorrhage from the femoral vein is well shown by one of Professor Agnew's operations for popliteal aneurism, wherein he wounded the femoral vein in passing the thread around the artery; "the venous hemorrhage, which for a time was profuse, immediately ceased on tightening the ligature, and did not afterward return."[2] It is not difficult to conceive how ligaturing the main artery of a limb aids in suppressing hemorrhage from the corresponding vein, for it greatly reduces the supply of blood to be returned by the wounded vein, and arrests the *vis a tergo* impulse which otherwise would be imparted by the arterial contractions to the circula-

[1] Op. cit., p. 171. Foot-note. [2] Op. cit., vol. i., p. 516.

tion in the wounded vein. The femoral artery was ligatured, in the case related above, about the year 1842, almost twenty years in advance of the famous advice of Langenbeck to the same effect, for suppressing hemorrhage from wounds involving large veins.

The axillary vein, in rare instances, has been ruptured during attempts to reduce old dislocations of the shoulder-joint:—

Froriep reported the first case: A scrofulous subject, aged 26, was found, twenty days after the accident, to have sustained a dislocation of the shoulder. At a second attempt at replacement, two distinct sounds were heard, and the dislocation became reduced; but, at the same moment, an axillary swelling appeared. The swelling rapidly increased. The patient fainted twice, vomited, went to stool, and expired one hour and a half after the reduction. The axillary cavity was found full of blood, and the axillary vein broken almost entirely across. Its coats were very weak above and below the rupture.[1] A *second* case belonging to the same category happened to Flaubert, in 1827. Some years ago, the late Mr. Price[2] was reducing, at the Great Northern Hospital, an old dislocation at the shoulder of an aged female, when the axillary vein, as was subsequently ascertained, was torn across, the patient dying on the following day. The artery was not ruptured. This made the *third* case. In 1863, a *fourth* case occurred to Hailey. In 1873, Professor Agnew observed and recorded a *fifth* case. A woman, aged 60, had a dislocated right shoulder of six weeks' standing. Steady and persevering extension was exerted for several minutes while an assistant's hand was held in the axilla to guide the head of the bone toward the glenoid cavity. A swelling suddenly appeared in the right pectoral region, distending in an instant the entire breast, rendering it exceedingly prominent, and forming a firm but fluctuating tumor. The patient instantly became cold and collapsed; respiration ceased, and the pulse could not be felt. The subclavian artery was compressed, the tongue drawn forward, and cold douches, ammonia, artificial respiration, etc., tried. The patient rallied, and on relaxing the pressure it was found that the radial pulse on that side was just as strong as on the other. The tumor was not tense and distended, and did not seem filling with any force. Compresses were firmly applied, with warmth externally and stimulants internally. The swelling slowly extended backward, but did not become more tense. In ten days she was discharged.[3]

Rupture of the axillary vein is more deadly than even rupture of the axillary artery. Of the five examples, Dr. Agnew's was the only one which ended in recovery. I have related it with considerable minuteness, in order to illustrate the symptoms and treatment of this accident. In some rare instances the axillary artery and vein are simultaneously ruptured during efforts to reduce old dislocations of the shoulder-joint. The chief danger in all these cases is that which arises from the subtegumentary bleeding; and unless adequate measures to restrain it are instantly taken, the patient will succumb to it. These measures are: (1) To compress the subclavian artery against the first rib; (2) to place an extemporized tourniquet, for instance, a handkerchief, around the upper end of the arm; (3) to confine the arm to the side of the chest with a firm bandage. In cases where the artery and vein are both ruptured, should the extravasation of blood happily be restrained from the first, and should the patient happily escape the perils which are denoted by the symptoms of shock and collapse, primary amputation of the arm at the shoulder-joint should be performed.

The great venous trunks may be ruptured in railway accidents, as happened in the following instance where the subclavian was involved:—

Valentine K., commissary department, was caught between the buffers of two railway cars July 20, 1863. The humerus, clavicle, and scapula were fractured, and the neigh-

[1] Malgaigne, Traité des Fractures, etc., t. ii. p. 151.
[2] St. Bartholomew's Hospital Reports, vol. ii. pp. 107, 108.
[3] Philadelphia Medical Times, Aug. 16, 1873.

boring soft parts were pulpified, although the skin was not broken. The arm sphacelated, and the man died on the 23d. The subclavian artery was obliterated where it leaves the first rib. The subclavian vein was torn open, and thus the extravasated blood with which the injured parts were distended had been supplied.[1]

The large veins sometimes get torn open when their coats are weakened by disease, as occurred in the following case where the internal jugular was ruptured during the performance of an operation for epithelioma of the neck:—

"The tumor was removed in September, 1876, the external jugular vein being tied. In March, 1878, the patient returned, and had the growth removed a second time. During the operation the internal jugular vein gave way, its walls being involved and softened, and was tied above and below. The patient made a good recovery, and in July, 1880, was known to be alive and well."[2]

When this accident occurs, the vein must be tied above and below without delay, as was done in this case; and when the internal jugular is the injured vein, it certainly is not necessary to tie the common carotid artery, as proposed by Langenbeck, unless its tunics are also involved in the disease for which the operation of removal is performed.

Spontaneous rupture of the internal jugular vein, with the formation of a cervical thrombus, etc., may occur, as happened in the following instance reported by Nélaton:—

The thrombus caused great swelling of the neck. It was opened to relieve the extreme dyspnœa which it produced by pressing on the air-passages, under the supposition that it was an abscess. The hemorrhage that followed was so copious that the incision was prolonged in order to bring into view its source, which was found to be an oval opening into the internal jugular vein. This Nélaton plugged with a cylinder of agaric, and the bleeding did not return. It came on during scarlatina.[3]

Moreover, the tunics of the internal jugular vein may be so much weakened by an abscess of a contiguous gland, that they will give way, and allow a thrombus of the neck to ensue; and if the issue of blood from the aperture in the vein cannot be controlled by the application of agaric and pressure, the vein itself must be ligated above and below the aperture with carbolized catgut. In those instances where the aperture in the wall of the vein is small, as it appears to have been in the case reported by Nélaton, the application of agaric with compression will probably succeed in restraining the hemorrhage.

Gunshot Wounds of Veins.—The nature and importance of the subject can be best shown by presenting brief abstracts of some examples:—

A soldier, aged 24,[4] was wounded May 22, 1863, and entered a general hospital on the 27th. The ball entered midway between the left trochanter major and the apex of the coccyx, passed obliquely through the lower part of the pelvis and upper part of the right thigh, and emerged in the right femoral region, one inch below Poupart's ligament. Patient stated that very profuse hemorrhage occurred immediately after the reception of the wound; and, at every considerable motion of the patient, blood escaped from the femoral orifice of the wound, despite the pressure of compresses. Urine escaped from both orifices of the wound. On the 30th, slight diarrhœa, accompanied by deep jaundice, appeared. On June 4, the patient expired. *Necroscopy* revealed that the prostate gland, at its junction with the bladder, was cut away; that there was

[1] Medical and Surgical History of the War, First Surgical Volume, p. 527.

[2] Medico-Chirurgical Transactions, vol. lxiii. (1880); also American Journal of the Medical Sciences, April, 1881, pp. 481, 482.

[3] Journ. de Méd. et de Chirurg., t. xxii., November, 1861, p. 499.

[4] Med. and Surg. Hist. of the War of the Rebellion, Second Surg. Vol., pp. 304, 339.

not much infiltration of urine; that the right ramus of the os pubis was shattered into fragments; and that the right femoral vein was widely opened by the wound. The specimen is preserved in the Army Medical Museum, and has been already figured in this work in the article on Gunshot Wounds. (See Fig. 300, Vol. II. p. 209.) The opening in the vessel is very large.

In this case death was due to anæmic exhaustion, the result of numerous small hemorrhages. The original orifice in the vein probably became enlarged by the separation of a slough. At the outset it appears to have been but small.

In the following example the femoral vein was cut almost in two by a pistol-ball. Death ensued from hemorrhage in about two hours, although what was thought to be efficient compression was applied to the wound:—

Private John Eberhardt, Co. A, 17th Infantry, aged 21, was shot on October 29, 1868, at Belton, Texas, by a ball from a Colt's navy-revolver, which entered the right thigh three inches below Poupart's ligament, internal to the sartorius muscle, passed backward and slightly upward, nearly severing the femoral vein, grazed the femur, internally, at the junction of the shaft and neck, passed through the gluteal muscles, and lodged under the cuticle opposite the great ischiatic notch. The patient, unaware of his wound, continued walking or running until he fell, faint from the loss of blood. He was seen some fifteen or twenty minutes after the occurrence; the missile was extracted, an efficient compress was placed over the wound, and stimulants were administered. But he never reacted. He died in about two hours from hemorrhage.[1]

This example supports my view, that in cases when the femoral vein is severed, or almost severed, the hemorrhage cannot be restrained by compression, unless by ligature of the femoral artery the supply of blood to the distal part of the limb is cut off at the same time. In cases where it is not advisable to tie the artery, the wounded vein should be ligatured without any delay above and below the aperture; or else primary amputation should be performed.

In the following case the femoral vein was injured together with the accompanying nerve. Death ensued in four days from the loss of blood and mortification of the leg:—

A citizen, aged 17, was wounded by Indians, at night, while sitting at a camp-fire, just outside the stockade of Fort Philip Kearney, on November 2, 1866. The missiles were supposed to be slugs from a shot-gun. Two entered the inner side of the right thigh, in the middle third, and passed through just behind the femur. Two others passed through the calf of the right leg; another comminuted the second joint of the right index finger. Liquor ferri persulphat. was used to arrest the hemorrhage, which was venous, and simple dressings were applied. The patient died on the 6th, from shock, venous hemorrhage, and gangrene of the leg. An autopsy revealed laceration of the femoral nerve and injury of the femoral vein.[2]

In a case reported on the same page, which I have already mentioned in another place, where the femoral artery and vein were both severed by a round pistol-ball, death occurred in a few minutes, from hemorrhage. In another case, reported on page 85, of the same circular, where the femoral artery and vein were severed in a shot wound, the man bled to death, notwithstanding the apparently prompt application of a tourniquet. In such cases as these two, however, the hemorrhage is mainly arterial. For injuries like those sustained by the citizen above-mentioned, namely, laceration of the femoral vein with laceration of a great nerve and shot-perforations of the calf of same leg, primary amputation should always be performed.

There is a case of gunshot wound involving the right femoral vein, recorded in the Medical and Surgical History of the War,[3] in which life was prolonged

[1] Circular No. 3, S. G. O., p. 86. [2] Ibid., p. 73.
[3] Second Surgical Volume, p. 339.

for eighteen days, although no particular effort appears to have been made to suppress the bleeding:—

A soldier was wounded October 5, 1864, by a conoidal ball, which entered the left side of the scrotum above the testicle, passed almost transversely to the right, and emerged anterior to the right trochanter major. The discharge from the wound was sanio-purulent, and frequently attended with venous hemorrhage, the latter becoming more copious daily. On the 23d the man died. *Autopsy*—The track of the missile was extensively ulcerated; the femoral vein was severed, and contained purulent matter. The spermatic cord was also severed. The shot-lesion of the femoral vein, in this case, was probably a contusion at the outset; the bruised portion of the vein-wall sloughed, and, as the slough separated, the canal of the vein was opened daily more and more. Thus the bleeding increased from day to day, until death ensued from the frequently-repeated hemorrhages. Perhaps, a patient similarly wounded might be saved by the use of antiseptic dressings and drainage-tubes in the track of the missile, together with deligation of the vein above and below the aperture, performed when the first bleeding appeared; and, with a view to deligation, it would be good practice in similar cases to explore the wound, enlarging it if necessary, in order to lay bare the source of the bleeding.

Another large vein, which is not unfrequently opened by small-arm missiles and portions of shells, is the *internal jugular*. The Army Medical Museum contains a specimen in point:—

"A wet preparation of a portion of the right jugular vein, wounded by a round bullet from a spherical case (shot). A part of the parietes of the vein has been carried away, and in the posterior portion an orifice is seen, through which the contributor considers the missile passed. Private H. O., 'A,' 5th U. S. Artillery, Suffolk, Va., 15th April; died 19th April, 1863."[1] In such cases, death ensues from hemorrhage, unless the vein is promptly ligatured above and below the lesion.

The next two examples will serve to show how insufficient styptics, and compression, and cold applications, and position are to restrain the hemorrhage from wounded jugular veins:—

A soldier was struck, July 18, 1863, by a piece of a shell, in the root of his neck, tearing open the branches of the thyroid axis and the internal jugular vein. Styptics and compresses, etc., were applied, because it was decided that to operate for ligation would hasten death on account of hemorrhage. He died on the 27th.[2] In a case like this the surgeon would be justified in assuming many risks rather than abandon the patient to otherwise almost inevitable death.

Again; Sergeant J. W. J., Jr., Co. D, 28th Mississippi Cavalry (Confederate), was wounded and captured, April 10, 1863. A conoidal ball entered his neck opposite the thyroid cartilage, at the inner border of the left sterno-mastoid muscle, and emerged about an inch and a half to the left of the lower cervical vertebræ. He lost, in the course of three hours, perhaps two quarts of blood, when the hemorrhage ceased. On the second day he was taken with severe chills, which recurred at the rate of two or three a day, followed by high febrile reaction. Death resulted on the 16th, that is, six days after the casualty. The *autopsy* showed the internal jugular vein completely divided; the surrounding tissues were extensively infiltrated with pus and blood; and the divided extremities of the vein contained a large amount of pus.[3] Had both ends of the severed vein been securely tied, without delay, in this case, not only would all bleeding have been suppressed, but also the entrance of purulent matter into the open mouths of the vein would have been prevented; and the patient would have had some chance of recovery. At least, the risk of death from purulent absorption would have been very much diminished by such a proceeding.

[1] Catalogue A. M. M., p. 470. Specimen 1055.
[2] Medical and Surgical History, etc., First Surg. Vol., p. 411.
[3] Ibid., pp. 411, 412.

S. Cooper has published a noteworthy instance of an oblique gunshot wound opening the internal jugular vein, in which death ensued from the pressure that was exerted on the air-passages by the subtegumentary extravasation of blood:—

A soldier was shot, the ball entering behind the mastoid process and passing downward and forward toward the sternum. The internal jugular was divided; the man lived more than an hour, but was suffocated by the pressure on the trachea of a large mass of extravasated blood which could not escape outwardly.[1]

Breaches in the walls of the internal jugular vein made by gunshot missiles sometimes heal spontaneously. There are at least two examples on record:—

Dr. Stromeyer saw, at Colding, a Schleswig-Holstein soldier who had been shot in the right side of the lower jaw, and across the neck under the tongue, the ball lodging and remaining unextracted. There had been no hemorrhage. The patient died, at the end of three weeks, from pyæmia. At the *autopsy* an abscess was found behind the left sterno-cleido-mastoid muscle, in which the flattened bullet lay near the vertebral column. "The internal jugular vein had been torn to the extent of five lines on its antero-outer aspect; but the rent was completely healed, as the coats of the vein had applied themselves to it from behind, and were united thereto, so that the cylinder of the vessel was diminished one-half."[2]

Dr. Schwarz observed the other case: A rifle-ball, entering the mouth, shattered the lower jaw, tore open the internal jugular vein, and, lodging at the aperture, restrained the bleeding. Suppuration ensued, with death from pyæmia. An *autopsy* showed a completely healed rent in the outer wall of the vein, the cylinder of which was slightly diminished, but free. At the cicatrix, the coats of the vein were thickened by plastic deposits, and a very adherent, semi-organized layer of lymph coated the lining membrane. The small veins contiguous to the abscess, in which lay the ball, were filled with broken-down coagula.[3]

The *prognosis* in gunshot wounds that involve the internal jugular vein is very bad. Dr. S. W. Gross was unable to find on record a single case of recovery from this lesion. "On the contrary, all the cases have proved fatal; 62.5 per cent. from secondary hemorrhage; 25 per cent. from pyæmia, and 12.5 per cent. from primary hemorrhage."[4] Recovery from gunshot lesions of the internal jugular must be very rare; for an extended search has failed to furnish me with even one undoubted case of such a recovery. The First Surgical Volume of the History of the War contains, however, the abstracts of two successful cases of gunshot wound of the neck, in each of which it is probable that the internal jugular was injured.[5]

Shot wounds of the *axillary vein* were occasionally noted during our late civil war; but no example was reported of a shot-wound of the *subclavian vein* that came under treatment. The case reported by Mr. Blenkins,[6] where a ball passed between the right subclavian artery and vein, wounding the latter and causing fatal phlebitis, remains the solitary recorded instance. But, as Mr. Fraser observes, the exemption is ideal rather than real, for probably a large proportion of those killed in battle die from torn blood-vessels.

Wounds of the Sinuses of the Dura Mater.—Brief mention must be made of the traumatic lesions which have been observed in the great venous

[1] First Lines of the Practice of Surgery, vol. i. p. 529. New York, 1822.
[2] American Journal of the Medical Sciences, January, 1867, p. 40.
[3] Ibid., p. 40.
[4] American Journal of the Medical Sciences, January, 1867, p. 36.
[5] Op. cit., pp. 412, 422.
[6] Fraser, Treatise on Penetrating Wounds of the Chest, p. 13.

canals of the encephalon. In the following example, the left petrosal sinus was lacerated by a fracture of the skull; death from cerebral compression speedily ensued:—

A young lady (Emma Leiding) in Brooklyn, on October 4, jumped off from an Atlantic Street horse-car, which was running away down hill, the brakes having failed. She alighted on her feet, but, in her fright, fell backward striking upon her head. She was immediately picked up insensible, having a scalp-wound on the back part of the head, and soon afterwards died without recovering consciousness. *Autopsy*, Oct. 5.—The only mark of violence found externally was a contused and lacerated wound of the scalp on the posterior part of the head. On opening the skull, a large quantity of uncoagulated (or liquid) blood was discovered in the cranial cavity. On removing the brain, the base of the skull was found fractured on the left side; the left petrosal sinus was ruptured, which accounted for the hemorrhage. No other lesions were present. Thus, the cause of death was cerebral compression, the result of extravasation of blood from a lacerated petrosal sinus. Moreover, extravasations of blood from wounds of this vessel are apt to prove quickly fatal, *first*, because they are rapid and copious, and *secondly*, because they directly compress the medulla oblongata. In such cases there is no return of consciousness. The insensibility of cerebral concussion is succeeded by that of cerebral compression, without any appreciable interval. Such cases are not remediable.[1]

Other cases, however, are remediable. For instance, Guthrie[2] reports the following case:—

A dragoon fell from his horse, in consequence of a wound in the trunk, on to the top of his head. Coma supervened. A swelling of the scalp was noticed at the vertex, where he had struck; this, on being incised, showed a separation of the edges of the sagittal suture, from which some blood flowed. Two crowns of a trephine were applied on the twelfth day, in order to obtain a free discharge of some blood which had been extravasated from a wound in the superior longitudinal sinus, after which the symptoms subsided, and the man gradually recovered.

M. Mouton mentions a similar instance in which he was called to see a man eleven days after a fall. The patient was insensible and almost dying, in consequence of an extravasation of blood from the superior longitudinal sinus, wounded by a separation of the sagittal suture. Trephining gave vent to the extravasated blood, and the threatening symptoms immediately ceased.[3]

Wounds of the longitudinal or lateral sinuses are not dangerous, provided the external opening is large enough to allow the blood to escape freely. But when the blood cannot escape in this way, such wounds are extremely dangerous from the attendant compression of the brain.

M. Lassus presented two cases in which the superior longitudinal sinus was opened by punctured fractures of the parietal bones at the sagittal suture. In each case a trephine was applied, the fragments or splinters of bone were pulled out of the sinus into which they had been driven, the bleeding was stopped by applying some dry lint to the rent in the sinus, and the patient made a good recovery.[4]

M. Gagnière has reported a case in which the superior longitudinal sinus was wounded by a blow on the top of the head with a dung-fork. He enlarged the opening in the scalp by a cruciform incision, and extracted the fracture-splinters; and he then perceived a clot of blood which had formed in the opening of the sinus, which had been made by the fork. The dressing, which was made in the manner usual after trephining, was moistened with spiritus balsamicus, a powerful antiseptic; no severe symptoms followed, and the wound was quite healed by the end of three months.[5]

[1] Mr. Prescott Hewett records a most extensive extravasation of blood between the bone and the dura mater, which proceeded from a rupture of the right lateral sinus, just as it turns under the petrous portion of the temporal bone, in a case of fracture. (Trans. Patholog. Soc. of London, vol. iii. p. 229.)

[2] Commentaries on Surgery, etc., p. 349, Am. ed.

[3] Memoirs of the Royal Acad. of Surgery of France, Sydenham Society's Translation, p. 8.

[4] Ibid., pp. 66, 67.

[5] Ibid., p. 69.

Percival Pott, in a hopeless case where the superior longitudinal sinus was laid bare by a compound fracture of the skull, for a space at least two inches in length, wishing to abstract blood, made an opening with a lancet into the sinus, and suffered the blood to run off until the countenance, which was flushed, became pale. He then put a bit of lint on the orifice, and by pressing thereon lightly with a finger, easily stopped the bleeding. This venesection caused no trouble. The patient, however, died on the twelfth day afterward, from a cerebro-meningeal abscess, due to the original injury.[1]

In some sabre wounds, which divide the skull across the sagittal suture, the longitudinal sinus has occasionally been opened and bled profusely, but without inducing fatal consequences. Hennen has seen this sinus opened by splinters, but never saw anything approaching to dangerous hemorrhage from it.[2]

In the case of a child, aged 3 years, the great longitudinal sinus was opened by a punctured fracture of the skull, made with the sharp point of a pickaxe; much venous hemorrhage ensued from a small wound over the sagittal suture; a probe inserted into this wound passed down to the corpus callosum. A pad of lint was applied to the wound, and an ice-bag was kept on the head; the patient made satisfactory progress to recovery.[3]

Foreign bodies lodged in a sinus of the dura mater do not readily excite intra-venous inflammation. For example, in December, 1868, one of the demonstrators of anatomy in the Calcutta Medical College met with a calvaria (now in the College Museum) in which an iron headless nail, about an inch long, had penetrated the frontal bone on the mesial line, and, passing completely through the longitudinal sinus, had divided the layers of the falx cerebri, between which its point is visible; consequently its shaft, which was not corroded, stood in the mid-current of blood in the sinus, and seems latterly not to have caused any inconvenience. The edges of the hole in the frontal bone, which the butt-end of the nail still occupies, are so rounded that it looks like an arterial foramen, and there is not the slightest trace of inflammatory change within.[4]

Lastly, I will state a few conclusions derived from the foregoing: (1) Wounds of the sinuses of the dura mater do not possess any peculiar elements of danger. (2) Hemorrhage from wounds of these sinuses is not dangerous unless the extravasation is retained within the skull; in which case it becomes very dangerous because of the compression of the brain that ensues. For its relief the operation of trephining should, if possible, be performed. (3) External bleeding from wounds of these sinuses can generally be restrained, without much trouble, by applying dry lint with slight or very moderate pressure. But, under no circumstances, should the persulphate or perchloride of iron be put in such wounds, because of the possibility of its getting into the injured sinus. (4) Antiseptic dressings should be applied, together with the ice-bag if there be any tendency to meningeal inflammation or to a cerebral abscess.

SEPTICÆMIA FROM WOUNDS OF VEINS.—A wounded vein or sinus of the dura mater, whose open mouth is surrounded by, or bathed in, purulent fluid, may afford an avenue for the introduction of septic matter into the circulation, which will infect the blood and the whole system, that is, produce septicæmia. Professor Agnew has seen a trifling wound of the cephalic vein, below the line of the deltoid, prove fatal from this cause.[5] The writer has seen a lesion of the same vein, made in opening an abscess of the arm, prove

[1] Chirurgical Works, vol. i. p. 134, Am. ed.
[2] Principles of Military Surgery, p. 231, Am. ed.
[3] Lancet, August 22, 1874, p. 270.
[4] British and Foreign Medico-Chirurgical Review, October, 1871, p. 353.
[5] Op. cit., vol. i. p. 516.

fatal in the same way. The extension of morbid processes from unhealthy wounds into the severed veins, through their open mouths, has often been observed. For instance, Dr. Macleod, in his Notes on the Surgery of the Crimean war, states: "We had many most beautiful examples, post-mortem, of veins leading from the stump remaining round, patulous, and filled with pus, and sometimes reddened in their interior. It was not uncommon to trace the pus-filled vein from the thigh to the vena cava."[1] There is no doubt that a septicæmic thrombosis is readily started in severed veins whose open ends lie uncovered in unhealthy suppurating wounds; and that this septicæmic thrombosis is much inclined to spread upward toward the right auricle. I have several times found such thromboses on examining, post-mortem, the bodies of those dead from gunshot fractures of the thigh and similar injuries. Hence, I think that Dr. Macleod, with much propriety, raises the question whether it would not be justifiable to ligature the chief veins of amputated limbs, at the time of the operation, especially, if the so-called purulent absorption should be an accident of common occurrence. He states that "numerous cases are on record in which the ligature of veins has not only not been followed by evil results, but has absolutely been the apparent cause of preventing inflammation and pus-absorption." This is particularly well illustrated in a case related by Mr. Johnston, of St. George's Hospital, in the journals of 1857. In that case, those vessels which had been tied were free from both inflammation and pus, while those not included in ligatures were full of pus, and "much inflamed." I do not doubt that ligatures applied to veins, in wounds likely to become the seat of unhealthy suppuration, may prevent the introduction of septic matter into the blood, as well as the occurrence of septicæmic thrombosis, and septicæmia itself. My views fully accord with Velpeau's, concerning the advisability of oftentimes securing wounded veins with ligatures, when he in substance says: "The dangers of ligation, which so many surgeons have insisted on for half a century, are shown to be farthest from the truth, and I should not be surprised to find that it would prove more advantageous to close veins immediately with ligatures, than to leave them open at the bottom of wounds."[2] Mr. Liston, too, feared the consequences much more when the ends of divided veins remained open in suppurating wounds, than when they had been closed by applying ligatures.

To prevent the occurrence of septicæmia or pyæmia in cases where veins of importance are wounded, it is advisable: (1) To secure the opened veins with carbolized catgut ligatures applied on the cardiac, as well as on the distal, side of the wound. (2) To treat the wound itself on the antiseptic plan. (3) To prevent any collections of purulent matter from forming or burrowing around the injured veins, by thorough drainage, and by frequent renewals of the dressings. In cases where the skull is injured, it is, likewise, very important to prevent any collections of matter from forming on the sinuses of the dura mater, by early incisions, by changing the dressings at short intervals, and by securing as good a drainage of the wound as possible.

Ligation of Veins.—When a delicate, strong, and well-waxed silk thread is drawn as tightly as possible around a large vein, its tunics become thrown into longitudinal folds or plaits. Upon slitting the vessel open, these folds are seen to be well marked, but without any division of the tunics; and by holding the vessel between the eye and the light, a decided transverse furrow or indentation, corresponding to the site of the ligature, is discernible, which

[1] Op. cit., pp. 350, 351, Am. ed.
[2] Operative Surgery, vol. ii. p. 2, Am. ed.

might at first sight appear due to injury of one or more of the coats. The external and internal tunics can be made to glide over the furrow by the finger, showing that some lesion exists in the middle coat, and a superficial examination would leave the opinion that it had been completely divided. A minute examination and dissection, however, clearly disclose that only the inner layer of the middle coat, consisting of circular elastic fibres, has been cut, or rather separated, leaving the longitudinal fibres unharmed and closely connected with the uninjured external tunic. With the exception, then, of the impression made upon the inner layer of the middle tunic, none of the coats suffer division. The external tunic seems to be as strong as that of an artery in resisting a ligature. The middle tunic differs from that of an artery in having longitudinal as well as circular fibres, the former being composed of white fibrous tissue with elastic fibres, the latter of elastic fibres arranged in the same manner as those of an artery, with an admixture of a large quantity of unstriped muscular fibres. The inner tunic is more dense and tough, but not nearly as lacerable as that of an artery, and can be stripped off from the middle coat much more readily and to a greater extent. The inner tunic of the ascending cava has been peeled off in one unbroken patch of more than two inches, and on applying a ligature to it, it suffered no division. It is thus seen that the anatomical structure of a vein differs materially from that of an artery, and that, when ligatured, none of its coats are completely divided, as is the case with the latter vessel.[1] Ligatures, however, when tightly drawn around veins, always make enough impression on the deep layer of the middle tunic to keep them from slipping off from the ends after the vessel is severed.

Subsequently, the changes wrought by the application of ligatures to veins are strictly analogous to those which take place in ligated arteries. A coagulum forms on the distal side of the thread; it becomes organized, and unites with the inner tunic. If a ligature of animal origin, such as carbolized catgut, has been applied, the approximated walls grow directly together, and the ligature itself disappears by absorption, or is replaced by new connective tissue. But if a ligature of silk has been employed, as it cuts its way through the vein by ulceration, the tunics at the ends unite either by the first intention or by adhesive inflammation, and the obliterated portion is ultimately converted into a firm fibro-ligamentous cord. Veins may, and often do, undergo repair after ligature without any inflammation whatever, whether adhesive or otherwise, as Mr. Travers was the first to show. Three preparations illustrate this fact. One, in the Museum of St. Thomas's Hospital, is thus described: "Appearance of a vein divided by the ligature, which came away on the twenty-fifth day. The upper part of the vein is filled with firm layers of coagula, which so tenaciously adhere to the inner membrane as to be separated with difficulty; when separated, the surface was found to be perfectly smooth and natural." A second preparation, in the Museum of St. George's Hospital, shows the result of a ligature applied to the jugular vein of a horse for twenty-four hours. The inner vein-wall, thrown into longitudinal folds, is otherwise natural in appearance, whilst a good deal of lymph is accumulated externally around the ligature. The third, also in the Museum of St. George's Hospital, shows the effects of a ligature including part of the parietes of the jugular vein of a horse. Some fibrin is deposited in the track of the thread and in a small pouch below, but no evidence exists of any inflammation of the lining membrane, and this three days after the application of the ligature.[2] The results of tying the internal jugular vein in man, which were observed by Guthrie and Langen-

[1] S. W. Gross, American Journal of the Medical Sciences, April, 1867, pp. 320, 321.
[2] Holmes's System of Surgery, vol. iii., p. 357.

beck, as already mentioned, teach the same important lesson. In both, union by the first intention occurred. In Guthrie's case of lateral ligation, the healing was so perfect on the ninth day that there was no mark to indicate where the thread had been applied. In Langenbeck's case, an autopsy on the twelfth day showed the "vein completely healed, without trace of clot, redness, or thickening of its walls," that is, without any trace whatever of any inflammation.

All surgical observations prove that ligatures may fearlessly be applied to veins, as Dr. S. W. Gross has ably shown in an exhaustive article on wounds of the internal jugular vein and their treatment, published in the American Journal of the Medical Sciences, for January and April, 1867. The danger of exciting phlebitis and pyæmia by ligaturing veins is an exploded doctrine among surgeons. The dread of setting up diffuse phlebitis by ligaturing veins is based on prejudice, and not on experience; it is doubtless due to the influence of authorities who have pronounced against the operation (Bryant). This doctrine had its origin in the mistaken views on suppurative phlebitis and thrombosis which were current among pathologists some years ago, but which have long since been abandoned. The truth is, as I have just shown above, that the judicious application to wounded veins of carbolized catgut ligatures, or any other good antiseptic ligatures of animal origin, will lessen much the risk of diffuse phlebitis, putrefactive thrombosis, septicæmia, and pyæmia. In hemorrhages, too, from wounded veins, the antiseptic ligatures just mentioned should be fearlessly applied whenever advisable to restrain the bleeding. Lateral ligatures, however, should not be employed, from the risk of secondary hemorrhage which attends their use, as Roux's experience, to which I have already referred, has amply shown. Some writers advise, in similar cases, to stitch together the aperture in the side of the vein with a fine thread; but this practice, likewise, is a dangerous one, and altogether unreliable. Whenever veins are ligatured, an antiseptic thread of animal origin must be made to encircle the whole vessel; and a separate ligature must be passed around it on each side of the aperture in its walls. Moreover, wounded veins should always be tied in this way without delay, when pressure, properly applied, fails to restrain the hemorrhage.

*Ligation of Artery and Vein simultaneously for Venous Hemorrhage.*—When a large vein is wounded and bleeding, Professor Langenbeck recommends that, as an hæmostatic measure, the accompanying artery should be tied as well as the injured vein. He believes that "when both artery and vein are tied, not only does gangrene not follow, but there is less disturbance to the capillary circulation than when the vein or artery alone is tied." He states that, by simultaneous ligation of both artery and vein, "an equilibrium is maintained between the arteries and veins until the collateral circulation is established." Two observations which I have already presented strongly support these views. One of them was a case related by the late Dr. George McClellan (page 202), in which, the femoral vein being lacerated, the femoral artery was ligatured, the hemorrhage was easily restrained by compression, and the result was successful. The other occurred to Professor Agnew (page 202); in it, the hemorrhage from a punctured femoral vein ceased on applying a ligature to the accompanying femoral artery, and did not recur. That gangrene is not an inevitable result, and is but rarely to be expected in such instances, is well shown by the cases of Professor Grillo, of Naples, who included the femoral artery and vein in the same ligature in fifteen cases of aneurism of the ham or lower part of thigh. These were all successful; while in fourteen other cases, in which the artery was isolated and tied alone, there were two deaths from secondary hemorrhage.[1]

[1] American Journal of the Medical Sciences, April, 1867, p. 334.

During the late civil war, in a case of secondary hemorrhage to the amount of twenty ounces, from a gunshot wound of the armpit, the axillary artery was ligated above and below the wound; and the axillary vein, being injured, was also tied. The bleeding did not recur, but death ensued on the thirteenth day after the operation, apparently from anæmic exhaustion. *Autopsy*—No evidence of phlebitis or pyæmia was found.[1]

In another case of secondary hemorrhage, the basilic vein, being open, was tied as well as the brachial artery, above and below the wound. This man recovered.[2] I have in one case, however, where the femoral artery and vein were both opened in a gunshot wound, seen gangrene ensue after the simultaneous ligation of these vessels:—

Private D. R., "K," 7th Indiana, aged 20; wounded November 30, 1863; a conoidal bullet passed from behind directly through the left thigh, dividing both femoral artery and vein, and escaping from Scarpa's space; admitted to hospital, Washington, December 6; operated on December 9, by Dr. Wm. Thomson, because the aneurismal condition was increasing. He laid the tumor freely open, and found the vessels severed just below the origin of the profunda. He tied each end of both artery and vein. Mortification of the limb followed, and death ensued on the 13th. I saw this case in consultation. Amputation was then out of the question. The man was very pale. His limb was already much swollen and œdematous, looking not unlike the limb in *phlegmasia alba dolens*. The aneurismal swelling was likely soon to burst. His general condition was failing. The operation was, therefore, one of expediency. In this case, the gunshot wound, the hemorrhagic infiltration, and the inflammatory swelling of the thigh, made the establishment of a collateral circulation much more difficult after the operation, which was performed on the ninth day, than it would have been had the operation been performed without any delay; and it is quite possible that, had the deligation of both artery and vein been practised at the outset, and before the advent of any swelling, the occurrence of gangrene would have altogether been avoided. At any rate, it is scarcely fair to infer that a primary ligation of the severed vessels would necessarily have been followed by gangrene.

When the femoral vein is wounded, but especially in the upper part of its course, it may be very difficult, or even impossible, to stay the bleeding, unless the femoral artery is ligatured. This fact is well shown by Oettingen's case:—

During the removal of a tumor situated in the fossa ovalis, he wounded the femoral vein, and therefore tied both ends of it. Notwithstanding this double ligation, the hemorrhage continued, and the leg became cyanotic. In order to arrest the venous hemorrhage, and to correct the inequality between the afflux and reflux of blood, he tied the common femoral artery. The hemorrhage ceased and the cyanosis disappeared. Gangrene did not ensue.

In a case recorded by Rose, there was a punctured wound of the femoral artery and vein, in a butcher, aged 25. Both vessels were ligated *in loco*, at their proximal and distal ends; the vein had been split by the knife, "directly under Poupart's ligament," the artery a little lower, "nearly under Poupart's ligament." The patient completely recovered, without even œdema of the limb appearing during the after-treatment.

Tillmanns ligated the common femoral artery below Poupart's ligament for profuse hemorrhage from numerous large veins, after the extirpation of a vascular sarcoma of the thigh, the size of a man's head. The hemorrhage was promptly arrested and the patient recovered.[3] Other examples of similar import might be adduced. Beyond doubt, then, it is often, perhaps generally, a good hæmostatic measure in wounds involving the femoral or axillary veins, to ligate the accompanying artery as well as the vein itself.[4]

[1] Medical and Surgical History, etc., First Surgical Vol., p. 555. [2] Ibid., p. 446.

[3] International Journal of Medicine and Surgery, vol. i. pp. 224–227.

[4] When hemorrhage from the common femoral vein makes deligation of that vessel necessary in order to stop the bleeding, the common femoral artery should also be ligatured in most cases, in order to equalize the circulation in the limb, as recommended by Langenbeck. "Under these circumstances, it may be hoped that still other successful ligations of the injured vena femoralis

Not so, however, in wounds involving the internal jugular vein. The great freedom with which the blood can pass from one jugular to the other through the lateral sinuses, etc., and can be returned toward the heart in this way in case one of them is ligatured, makes it quite unnecessary to tie the common carotid artery in order to equalize the afflux and reflux of blood in the head, when the corresponding jugular vein is closed by ligation. For the same reason, the ligation of a common carotid artery will not restrain the flow of blood from a wounded fellow internal jugular vein; and, therefore, it must be rejected as a hæmostatic measure in such cases.

Entrance of Air into Veins.—The entrance of air into veins is a most dangerous accident. I can describe it most briefly and accurately by presenting some examples. The first instance on record was observed in 1818 by M. Beauchesne, while removing a large tumor from the right shoulder. He accidentally opened the external jugular vein, just above its termination in the subclavian, during the extraction of a part of the clavicle; air entered the partly divided vein, and in a quarter of an hour the patient died. In 1822, a striking example of this mishap occurred to Dupuytren:—

He was excising a tumor from the postero-lateral part of the neck of a healthy young woman, and, while an assistant raised it up, as he was severing its last attachments a prolonged blowing sound was heard in the wound. "If I were not so far from the air-tubes," said Dupuytren, "I should think we had opened them." The words were scarcely uttered when the girl exclaimed, "Je suis morte;" she trembled, and fell dead. A large vein, connected with the tumor and communicating with the internal jugular, was cut by the last stroke of the scalpel while the tumor was forcibly drawn up. This vein adhered to the sides of a sulcus, so that it remained gaping when cut. The right auricle was found distended with air, which rushed out, unmixed with blood, on laying it open; the other chambers of the heart contained fluid blood. In all the vessels there was much air mixed with blood. No other abnormity was observed.

Many examples of this accident have been reported. In 1829, Amussat had already collected thirty-nine cases. They continued to happen with considerable frequency until the use of anæsthetics during surgical operations became general. Since that time, their occurrence has been very rare. Indeed, it is not difficult to perceive that anæsthesia, by eliminating from surgical operations on the neck, breast, and armpit, the struggles, cries, groans, and sobs, and the deep gasping inspirations they cause, which formerly obtained, must considerably diminish the risk of air being drawn into wounded veins, in those regions, by the suction power of the chest.

Two examples, however, were reported during the late civil war. In one of them, death occurred within two minutes, in the other in from seven to ten minutes after the mishap.

The following is a brief account of these cases:—

1. Private E. M. D., Co. E, 1st Maine Heavy Artillery, aged 21, was wounded May 12, 1864, by a conoidal ball, which fractured the left temporal bone and lodged in the neck. On May 22, during an operation for extracting the ball and fragments of bone, hemorrhage from the internal jugular vein took place, and within two minutes death occurred. Surgeon N. R. Mosely, U. S. Volunteers, ascribed the almost instantaneous death of this patient to the entrance of air into the internal jugular vein, which was

communis at the ligamentum Poupartii may be added to those already known, the more so, as by means of the antiseptic method of operating, uninterrupted recoveries are more easily obtained; that is, diffuse inflammatory infiltrations of the soft parts and extensive phlebitis are prevented. And especially as these compressing, extensive inflammatory infiltrations with phlebitis are very probably the main cause of gangrene after ligation of the arteries as well as after ligation of veins." (Tillmanns.)

found largely opened by ulceration.[1] This case is probably unique, for Dr. S. W. Gross asserts that there is not a single recorded instance of death from this accident following a gunshot injury of the internal jugular vein.

2. In the next example of air in veins, the axillary vein was accidentally opened while searching for the artery: Private E. C. Melley, Company K, 2nd West Virginia Mounted Infantry, was wounded November 6, 1863, by a musket-ball, which entered one inch and a quarter below the middle of the clavicle, and emerged near the middle of the inferior border of the scapula. When admitted to hospital on the 18th, an enormous tumor of coagulum distended the axillary space in every direction, and rendered the surrounding tissues tense; the subcutaneous veins covering it were enlarged. During his removal to hospital, considerable blood was lost from the anterior orifice; the posterior orifice was closed and nearly healed. On the 19th, an attempt was made to secure the axillary artery in the midst of this immense clot, at the place where it was wounded. But, in searching for the artery, the axillary vein was accidentally opened; the entrance of air caused syncope, and death ensued in from seven to ten minutes. After death the axillary artery was found almost completely divided about one inch before it becomes the brachial.[2]

This accident has most frequently been observed in the great veins at the root of the neck and in the armpit. The internal jugular was the seat of the mishap in twelve instances collected by Dr. S. W. Gross, with six deaths and six recoveries. Ten of them occurred while extirpating tumors of the neck, with five deaths and five recoveries; and two in cut-throats or attempted suicides, with one death and one recovery.[3] To these twelve cases a thirteenth, just now related, must be added, in which death from air in veins followed a gunshot lesion of the internal jugular. Moreover, these cases show that the accident is more liable to occur when the vein is opened near its termination in the innominate, as at this point, as well as throughout almost the whole of its lower third, the phenomena of venous inspiration may be witnessed, that is, the free sucking of air and blood, at each inspiratory effort, into the open mouth of the vein, when wounded or divided by an external injury.

This accident, too, has not unfrequently occurred in the subclavian and axillary veins. I have already presented one example in which the axillary was wounded, that occurred during our civil war. In a case recorded by Delpech, there was hypertrophy of the axillary vein, causing it to gap like an artery, so that the air entered in when it was opened.

Bransby Cooper[4] having secured the vessels after amputating an arm at the shoulder-joint, proceeded to remove a gland from the axilla, and, while dissecting it out, heard a peculiar gurgling noise, like air escaping with fluid from a narrow-necked bottle; the patient instantly became collapsed; countenance deadly pale; pupils fixed and inobedient to light; pulse quite small and fluttering, although, at intervals, regular; respiration hurried and feeble, and, at irregular intervals, attended with a deep sigh; left leg apparently paralyzed. She continually uttered a whining cry. Symptoms of great prostration continued for several days, but she eventually recovered. When she left the hospital, six weeks after the operation, she still dragged the left leg in walking.

While Roux was disarticulating an arm at the shoulder by the method of Desault, a peculiar whistling sound of air was suddenly and very distinctly heard. Pallor, syncope, convulsive movements, and death ensued. *Autopsy*—Right ventricle soft, and distended with a mixture of air and blood; globules of air in the coronary veins; contents of vena cava superior, spumous.[5]

[1] Med. and Surg. History, etc., First Surg. Vol., pp. 255, 256.
[2] Ibid., p. 555.
[3] Loc. cit., pp. 38, 39, 329, 333, 338, 339.
[4] Medico-Chirurgical Transactions, vol. xxvii. p. 14.
[5] Journal des Connaissances Médico-Chirurgicales, Septembre, 1836, pp. 108, 109.

Dr. Mussey, in 1837, extirpated the clavicle and scapula, six years after amputating the arm. At the moment of tying the subclavian artery, a faint gurgling sound was heard, and a bubble of air was seen in the mouth of the subclavian vein. The man uttered a faint cry; his eyes rolled and became fixed; his neck and face were covered with cold sweat; his pulse was imperceptible; there was loss of consciousness during eight or ten minutes; finally, however, the patient recovered.[1]

Mr. Jessop did a primary amputation of the upper extremity, including the scapula and outer half of the clavicle, for a severe injury.[2] While removing the scapula, air was heard to enter the subclavian vein. The patient was suffering from extreme shock at the time, and was almost dead; but he rallied, and at the end of three weeks the wound was healed.

The spontaneous entrance of air into the venous system has also occurred, not unfrequently, during surgical operations which laid open the lesser veins of the sub-clavicular, axillary, and sub-scapular regions, as well as those which involved the subclavian and axillary veins.

For instance, on July 4, 1837, Amussat extirpated the right mamma, and, while cutting into some suspected tissue under the right clavicle, he suddenly heard a distinct interrupted sound, as of air passing into a cavity through a narrow opening. Syncope, with cold sweats, etc., ensued, but in the end recovery took place. So, too, a case occurred to Warren, in which the air entered by the sub-scapular vein, the coats whereof were healthy, but in a state of tension, in consequence of the position of the arm. In a case reported by Castara, there was incomplete section of a vein which opened into the sub-scapular, whilst the tumor was raised up, and in this way the air entered.[3]

I have thus presented nine examples in which air was drawn into the veins of the axilla, both great and small, by the movements of thoracic inspiration, during operations for amputation as well as for the extirpation of tumors.

But air has often been drawn into the small veins of the neck when wounded, as well as into the large or deep jugular vein, by the movements of thoracic inspiration. I have already presented two such examples. In Dupuytren's case, a vein communicating with the internal jugular was cut. In Beauchesne's case, the external jugular was partially divided. Besides, there are on record at least three other cases in which air was sucked in through a wounded external jugular vein:—

Rigaud[4] opened a vein which he believed to be the external jugular, while ligaturing the subclavian artery above the clavicle. The sound of the drawing of air into the vein was heard three different times.

Malgaigne relates a case in which the accident happened in consequence of the incomplete section of the external jugular vein, where it was enveloped by a tumor that was being removed.

Manec, while ligaturing the subclavian artery for aneurism, opened the external jugular vein, and air was drawn in. The patient's head was thrown back; the eyes were convulsed; the face became pale; but recovery followed.

Again, the same accident happened in a case reported by Warren, in consequence of the division of a small transverse branch of communication between the external and internal jugulars, whilst in a state of tension.

Moreover, this mishap has ensued from the wounding of a small vein high up in the neck. For instance, Mott, on dividing the facial vein while removing a parotid tumor, heard the gurgling sound of air passing into some small opening. "The breathing of the patient immediately became difficult and laborious, the heart beat violently and

[1] American Journal of the Medical Sciences, February, 1838, p. 390.
[2] British Medical Journal, January 3, 1874.
[3] American Journal of the Medical Sciences, November, 1837, p. 233.
[4] Thèse. Paris, 1836.

irregularly, his features were distorted, and convulsions of the whole body soon followed to so great an extent as to make it impossible to keep him on the table. He lay on the floor in this condition for nearly half an hour, as all supposed him in *articulo mortis*. As the convulsions left him, his mouth was permanently distorted, and complete hemiplegia was found to have ensued; an hour or more elapsed before he could articulate, and it was nearly a whole day before he recovered the use of his arm and leg."[1]

Le Gros Clark mentions a case belonging to the same category, but also remarkable for the slowness with which the air was sucked into the vein, and the tardiness with which the symptoms appeared.[2] The incision was above the hyoid bone. Dyspnœa came on gradually, and increased until death ensued, in about twenty-four hours. At the *autopsy*, the blood in the heart was found churned up and frothy. Examination of the wound showed that a half-divided vein, ligatured only on the distal or bleeding side of the aperture, had slowly drawn into its open mouth the air which, admixed with the blood, had proved fatal.

"*Dangerous Region.*"—That there is a space of considerable size, embracing portions of several regions, in which there is a special danger in performing surgical operations, caused by the liability of air to be drawn into wounded veins by the movements of thoracic inspiration, these thirty examples just presented very clearly prove. They also show that this dangerous space embraces almost all of the cervical region, together with the sub-clavicular, the axillary, and the sub-scapular regions, and that the liability to get air in veins increases, on either side, with growing nearness to the brachio-cephalic trunk or the innominate vein. They show, too, that the careless gashing of small veins within these limits is almost as dangerous as that of the large ones; and that the veins to be especially avoided are the external and internal jugulars, the subclavian, the axillary, the thoracics, and the sub-scapular. The operations that need most caution in this regard are amputation at the shoulder-joint, disarticulation of the clavicle and scapula, deligation of the subclavian and other arteries, and the extirpation of tumors, from those consisting of scrofulous glands no larger than a small nut, all the way up to those as large as a child's head.

I must mention some examples of air in veins, which, although not of special interest to operating surgeons, still have enough of importance to demand recognition in this place. For instance, a case is mentioned by Dr. S. W. Gross in which air entered a large vein that was opened by ulceration. One of the jugulars communicated with an open sore through an aperture in its walls made by ulceration. There was a slight bleeding, followed by a gurgling sound, etc., and alarming syncope; from which, however, the woman gradually recovered under the use of stimulants.[3]

Dr. Cordwent relates a case in which he thinks death was caused by air entering the veins of the uterus after labor.[4] Professor John C. Dalton, Jr., mentions a case in which a gutta-percha catheter was used to rupture the membranes and procure abortion. The patient fell back and died. Air was found in the veins and heart; and it was believed by the surgeon that air had been blown in through the catheter, in order to produce the effect desired.[5] Depoul related to the Surgical Society of Paris a case in which the douche was used for the purpose of inducing premature labor. A gurgling noise, like that of air, attended the use of the instrument; and suddenly the woman died. On making the Cæsarian section for extracting the child post-mortem, air escaped in cutting into the uterus; the uterine tissue was bright red, and the blood was frothy.[6]

Dr. Parise observed several cases of sudden death in gangrene of the limbs, and in each instance believed that this result was caused by the entrance of putrid gas into the

[1] Gazette Médicale, 1831. [2] British Medical Journal. August 21, 1869.
[3] American Journal of the Medical Sciences, April, 1871, p. 337.
[4] St. George's Hospital Reports, vol. iii.
[5] American Medical Monthly, June, 1860. [6] Lancet, July, 1860.

veins, and thus into the heart. Maisonneuve, in 1853, published several cases of rapid gangrene with the development of putrid gas in the veins; but he believed that death was caused by blood-poisoning from this source. Dr. Parise, however, affirms that the putrid quality of the gas determines no septic action, but that the gas produces death in the same way that air does when it accidentally enters the veins.[1]

The entrance of air or gas into the veins caused sudden death in one case during the Crimean war: A soldier, aged 20, sustained a gunshot fracture of the left leg, June 18, 1855. On September 21, amputation immediately above the knee was performed; but the stump did badly, the discharge being thin, watery, copious, and slightly fetid. At 1 A.M., on the 25th, he was found, unexpectedly by the orderly, quite dead in bed, and nearly cold, although he had conversed with the man in the next bed as late as 11 o'clock. *Autopsy*—Lungs healthy, but somewhat anæmic. Right auricle distended with bright red froth (air or gas mixed with blood); right ventricle also distended, but the proportion of air was less; heart otherwise healthy. Inferior cava, too, distended with scarlet-colored, frothy blood, "so that it felt like a portion of small intestine before it was cut into." Interior of stump sloughy, with no attempt to unite; flaps separated to some extent by fetid gas; the femoral vein lay quite open on the face of the stump, with no attempt at closure, but no sloughing.[2] Had the femoral vein been ligatured in this stump, such a mishap could not have occurred.

*Causes.*—The above presented examples of this accident that took place in the dangerous region, show its causes to be the following: (1) The suction-power exerted by the inspiratory movements of the thorax upon the innominate and its tributary veins throughout the dangerous region. This suction-power is exhibited by a movement of afflux and reflux of blood in these veins, synchronous with the inspiratory and expiratory movements of the thorax. (2) The gaping of the mouth of the wounded vein which solicits the air to enter. This gaping in many situations is due to the adherence of the fascia or aponeurosis to the sides of the vein, whereby it is held open when wounded or divided. The contractions of the platysma and other muscles of the neck have a similar effect. (3) The "canalization" of veins, or their conversion into rigid, uncollapsing tubes—(*a*) from inflammatory thickening of their tunics, (*b*) from being surrounded by indurated connective tissue, or (*c*) from being imbedded in tumors—is an exceedingly favorable condition for the introduction of air into them. (4) The patulous state of veins may be caused by the surgeon himself in lifting up tumors, in making the neck tense by extending the head, in making the axilla tense by extending the arm, also by notching the walls of veins, and, finally, by neglecting to place a proximal as well as a distal ligature around a wounded vein, as happened in the case mentioned by Le Gros Clark.

*Symptoms.*—When the air enters a wounded vein, a whistling, hissing, sucking, gurgling or lapping sound is usually heard; bubbles of air often appear in the wound; a deathly pallor spreads over the face; the pulse becomes small and weak, or nearly imperceptible, and the heart's action laboring, rapid, and feeble; the respiration is labored or embarrassed, short, and hurried; the eyes are fixed, and the pupils widely dilated; if the quantity of air admitted be small, these symptoms may disappear after a time, and recovery ensue; but if the quantity be large, syncope with convulsions and fatal collapse soon follow. The symptoms, however, may be masked by the anæsthetic action of chloroform or ether. Hence the reports of cases of this accident are, as a rule, much less dramatic since the introduction of anæsthesia. It is not improbable that some of the deaths attributed to chloroform have in reality been due to air in veins.

A whistling, hissing, or sucking sound which is not due to the entrance

[1] Archives Gén. de Médecine, Novembre, 1880.
[2] Medical and Surgical History of the Crimean War, vol. ii. p. 277.

of air into a wounded vein, is sometimes heard during operations in the dangerous region. It may occur on opening the deep fascia of the axilla when made tense by extending the arm, or that of the neck when made tense by extending the head, or that of any space similarly protected from atmospheric pressure. Of course there are no constitutional symptoms in such a case. The following is a good example:—

In 1830, Professor A. H. Stevens, at the New York Hospital, while extirpating a large flattened tumor under the left sterno-mastoid muscle, having detached it completely, except at its postero-inner edge, drew the tumor outward and forward, and divided, near its junction with the internal jugular, a vein of considerable size. Half an ounce of venous blood escaped; in an instant afterward a peculiar sound, like that caused by drawing into a syringe the last portion of water from a basin, was heard. "It was a moment of intense anxiety," says Professor Stevens, "for the fate of Dupuytren's patient was fresh in my recollection. I immediately placed my finger on the aperture in the vessel, seized the pulse with my other hand, and watched the patient's countenance. All seemed well, and the patient's reply to my interrogatory confirmed the favorable indications." He treated the wounded vein by ligaturing the internal jugular above and below its place of entrance. The ligatures came away on the fourteenth day, and the case went on without any peculiarities.[1]

The following is likewise a pseudo-example of air in the veins:—

Professor Verneuil, while removing a tumor of the right parotid gland, divided a vein (the external jugular or one of its branches) while separating the supra-clavicular prolongation of the tumor; a whistling sound indicated the passage of air into the vein; the latter was instantly compressed, then tied; but no change occurred in the pulse or breathing. The operation was completed, and the case progressed satisfactorily afterward.[2] It is far more likely, however, that the air did not enter the vein at all, but, instead thereof, passed into the loose connective tissue under the deep cervical fascia, in this as in the preceding case.

*Pathology.*—Examinations after death from this accident show air mixed with blood in the right auricle and ventricle, often beaten up together into a spumous froth, with a similar spumous froth in the superior cava and other veins, and an unusually bloodless appearance of the lungs. Several explanations of the cause of death have been offered, none of which, however, are quite satisfactory. Among the most plausible of them is that which supposes that the air is carried into the right ventricle, and that, during the contraction of the right ventricle, the presence of this air prevents the closure of the tricuspid and the semilunar valves, in consequence of which the two orifices which they guard remain pervious in both the systole and diastole of the heart, allowing the air to reach the pulmonary arteries, and in this way preventing the entrance of blood; hence there is a deficient supply of blood to the brain and nervous centres, and fatal syncope comes on, attended generally by convulsions. The heart's action usually continues some time after respiration has ceased. Some who have recovered from the immediate effects have died from pneumonia.

*Treatment.*—The securing of equal and regular breathing in the patient, throughout operations in the dangerous region, by duly regulating the administration of anæsthetics, is an important precaution against this accident, which should never be neglected. The surgeon himself should avoid all the causes of this accident which depend upon his own conduct during the operation. There should be as much relaxation of the parts allowed as may be compatible with the safe or convenient performance of the operation. The

[1] Cooper's Surgical Dictionary, Supplement, Am. ed., pp. 165, 166.
[2] Gazette Hebdomadaire, 1863, p. 722.

relations of the veins should always be considered before any incisions are made, throughout the operation. Tumors should be detached from their surroundings, as far as practicable, with the handle instead of the blade of the scalpel; and all veins which it is not necessary to cut should be pushed aside. When it is necessary to divide a vein in the course of the operation, pressure should be made above and below, and should be continued on the cardiac side until the end of the divided vein is securely tied. But especially, when prying out adherent tumors from the deep parts of the neck, or of the axilla, should the surgeon have firm pressure made by his assistants upon the contiguous veins, both above and below. When disarticulating the clavicle, special pains should be taken to avoid notching the external jugular vein. When deligating the subclavian artery, special pains should also be taken to avoid wounding the same vein. In amputating at the shoulder-joint, the liability for air to enter the axillary vein, when cut into while the arm is extended, should be suitably met by the application of pressure.

But should, unfortunately, the air enter a vein, the surgeon must immediately place a finger on the orifice, and pass a ligature around the wounded vessel, on the cardiac as well as on the distal side of the aperture. By seasonably stopping the ingress of air in this way, many subjects of this mishap have been saved. The symptoms of alarming syncope, and the threatened collapse, must be met by lowering the patient's head, by artificially maintaining the respiration, and by the subcutaneous or rectal administration of diffusible stimulants, such as ammonia and brandy. It may, too, be remembered with possible advantage that dogs have been restored by artificial respiration continued for one-half or three-fourths of an hour, when very considerable quantities of air had entered the veins. As a remedial measure of last resort, if time permit, a few ounces of blood may be transfused.

## Wounds of the Aorta, Innominate, and Subclavian Arteries; the Venæ Cavæ, and Venæ Azygos; the Heart, Pulmonary Artery, and Pulmonary Veins.

Brief mention must be made of this important class of injuries. Wounds of these vessels very rarely come under surgical treatment. The subjects almost always perish from hemorrhage, or from shock, before surgical aid can be obtained.

Wounds of the Aorta.—The following example in which the *aorta* was punctured by the blade of a penknife is to the point:—

James Donohue, aged 8 years, living in the rear of No. 90 Catharine Street, went out about 9 o'clock P. M., on May 1, 1881, to buy an apple. In a few minutes he came back, and meeting his sister, said: "A boy as big as you are has stabbed me." There was a small wound in his breast, and soon he fainted in his sister's arms. He failed rapidly, and although he was taken in an ambulance to the Chambers St. Hospital, he died before midnight of internal hemorrhage. The wound was made with the narrow blade of a penknife, which entered the chest just below the third rib, and punctured the aorta. Afterward, it was shown that the stabbing had been accidental. He lived about two and a half hours.

During the civil war no one wounded in the aortic arch, or in any part of the *thoracic aorta*, lived long enough to receive hospital treatment. Dr. J. B. White mentions a case of bayonet-stab causing a small puncture in the aorta, a few lines external to the pericardium, which proved fatal from hemorrhage. But, since the war, Dr. W. J. Piper reports an accidental pistol-ball perfora-

tion of the aortic arch, the wounded soldier having lived long enough to be carried across the parade-ground to the post hospital, at Baton Rouge.[1]

But in the following example, where the *abdominal aorta* was injured in the late civil war, the patient survived the casualty forty days:—

A soldier was wounded, on July 3, 1863, by a conoidal ball, which entered his chest at the right nipple, and lodged. He did badly. About August 1, he rapidly grew worse. A pulsating tumor was discerned in the umbilical region, which steadily grew larger. He sank gradually, and died on August 12, of anæmia. *Autopsy*—The missile, entering the thorax at the right nipple, passed inward, downward, and backward through the diaphragm, by the side of the aortic sheath, and lodged in the body of the fifth lumbar vertebra, half an inch to the right of the median line. Just above the point of lodgment, a large aneurismal sac communicating with the aorta was found; it was partially emptied, and there was a large quantity of coagulated blood found extravasated beneath, that is, external to the peritoneum, on the left side of the spine, amounting to almost two pounds. The aorta, elsewhere, was healthy.[2] The bullet grazed the sheath of the aorta, in this instance, and its tunics, being weakened by the textural disintegration, gradually yielded until they burst and allowed a traumatic aneurism to form.

Wounds of the great bloodvessels of the trunk are usually passed over cursorily by systematic writers on surgery, and the information concerning them is scattered through theses, monographs, and collections of cases. Guattani[3] records the case of a man who survived an incised wound of the arch of the aorta eight years. Pelletan[4] relates the case of a man who lived two months after a puncture of the aorta, near its origin, by a foil. Heil[5] details a case in which the patient lived twelve months after receiving a stab in the ascending aorta. T. M. Green, of Macon, Ga.,[6] publishes an account he had from Dr. J. B. Wiley—"a competent and reliable observer"—of an autopsy held on a man stabbed, a month previously, in the aorta near its origin, with a narrow blade. In the *Journal de Médecine*[7] is a similar history, of a man who lived six days. Lerouge inserted in Saviard's *Observations Chirurgicales*, which he edited, a similar case, the patient surviving eleven days. Legouest[8] quotes a unique instance of recovery from a punctured wound of the aorta, observed by Dr. Neil, of Bamburg, in 1812, the cicatrix having been verified a year subsequently, at the autopsy, after the occurrence of death from pneumonia Demme saw a young Austrian perish from secondary hemorrhage four weeks after the reception of a gunshot injury of the descending part of the thoracic aorta. Cases of rupture of the aorta from external violence have been recorded by Morgagni,[9] Laurencin, and St. Leger,[10] and a specimen of this lesion is preserved in the Museum of St. Bartholomew's Hospital.[11] There is also a preparation by Professor Theile in the Museum of Pathological Anatomy, at Bern, showing a laceration of the arch of the aorta which was not fatal until several months after the accident.

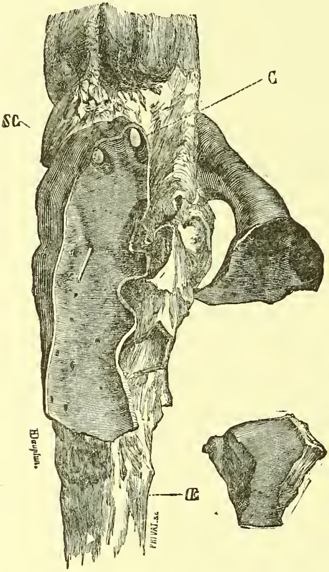
Our Army Medical Museum contains two specimens of gunshot lesion of the abdominal aorta, in one of which the artery is fairly perforated by a pistol-ball.[12] M. Legouest[13] saw a case of transverse laceration of the left side of the aorta, one-fourth of an inch long, three fingers-breadth above

[1] Med. and Surg. Hist. of the War, etc., First Surg. Vol., p. 519.
[2] Ibid., Second Surg. Vol., p. 189.
[3] Scriptorum Latinorum de Aneurismatibus Collect. ed. Lauth, pag. 178. Argent, 1785.
[4] Clinique Chirurgicale, t. iii. p. 241.
[5] Henke's Zeitschrift, 1837, Bd. ii. S. 459.
[6] Southern Med. and Surg. Journal, 1855.
[7] Journal de Médecine, t. xlvi. p. 435.
[8] Chirurgie d'Armée, 2e éd., p. 333.
[9] De Sedibus et Causis Morborum, Epist. liii.
[10] Thèse de Montpelier (MS.), quoted by Bérard.
[11] Med. and Surg. History, etc., First Surg. Vol., pp. 519, 527, Foot-notes.
[12] Specimens 910, 4085, Sect. I., A. M. M.
[13] Op. cit., 2me éd., p. 372.

the promontory of the sacrum, in a farrier, who received a kick from a horse at the level of the umbilicus. The bleeding, which, of course, was internal, proved rapidly fatal. Doubtless other arteries of the abdomen may be ruptured without external wound.

The aorta has occasionally been punctured by foreign bodies which had entered it from the œsophagus. I have already presented two such examples in the section on Punctured Wounds of Arteries. The aorta, too, has not unfrequently been opened by ulcerations caused by foreign bodies penetrating it from the œsophagus. The next four wood-cuts illustrate this accident.

Fig. 426.




Perforation of the aorta by a swallowed bone. The point of perforation is indicated by a stylet. *C.* Carotid artery. *SC.* Subclavian artery. *Œ.* Œsophagus. The bone is represented at the side. After Shetter (Archiv f. klin. Chir., 1878). Taken from Poulet's Foreign Bodies in Surgical Practice, vol. i. p. 90, Am. edition.

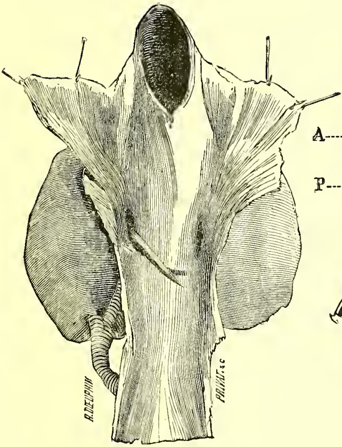
Fig. 427.

Perforation of the œsophagus and aorta by a five franc piece. (Denonvilliers, Musée Dupuytren.) Taken from Poulet's Foreign Bodies in Surgical Practice, vol. i. p. 93, Am. ed.

Poulet[1] has collected thirty-three instances of the perforation of bloodvessels by foreign bodies lodged in the œsophagus. In these cases, however, the perforations were effected by *ulcerations* caused by the foreign bodies, that is, the perforations were secondary to eschars, which, by gradually becoming deeper, finally involved the walls of the vessels. In 17, or over one-half of these 33 cases, the *aorta* was the vessel perforated ; in 4 the *common carotid artery ;* in 2 the *vena cava ;* in 1 the *inferior thy-*

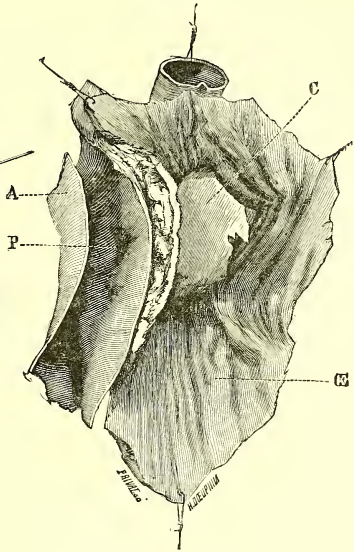
[1] Foreign Bodies in Surgical Practice, vol. i. p. 91, Am. ed.

Fig. 428.




Perforation of the inferior thyroid artery by a swallowed bone. (Pilate, Musée Dupuytren.) Taken from Poulet's Foreign Bodies in Surgical Practice, vol. i. p. 94, Am. edition.

Fig. 429.




Perforation of the aorta and œsophagus by a very irregular bone. (Bousquet, Musée Dupuytren.) *A.* The aorta. *P.* The perforation. *C.* The foreign body. *Œ.* The opened œsophagus. Taken from Poulet's Foreign Bodies in Surgical Practice, vol. i. p. 95, Am. edition.

*roid artery;* in 1 *the right coronary vein;* in 1 the *vena azygos;* in 1 the *right subclavian artery* (abnormal); in 1 the *œsophageal arteries;* in 1 the *pulmonary arteries;* and in 4 cases the arteries penetrated were *unknown*, as autopsies were not made.

The position of the œsophagus in the midst of the large vascular trunks of the neck and chest sufficiently explains the frequency of this grave accident. These vessels are: 1st, the aorta, which is situated behind and to the left of the œsophagus; 2d, the vena azygos; 3d, the pulmonary artery; 4th, the superior vena cava; 5th, the carotid; 6th, the inferior thyroid artery; 7th, the right subclavian artery, when abnormally situated; 8th, the œsophageal arteries. The much greater frequency of aortic perforations is not wonderful, in view of its great size, and of the intimate manner in which the two organs are connected over a considerable space.

The foreign bodies causing this accident have most often been pieces of bone. Next in the order of frequency are coins, fish-bones, artificial teeth, etc., and any irregular, dense, flattened, or pointed body can produce it. After what lapse of time are these perforations of bloodvessels developed? This period is very variable. In a large majority of the cases, however, the first hemorrhage occurs from the fifteenth to the twenty-fifth day; but the exceptions are numerous. Moreover, surgical interference is not immaterial; and, more than once, it has happened that the surgeon has forced a foreign body, which he thought he had pushed into the stomach, into the œsophageal walls. Such a manipulation would only, by so much, hasten the occurrence of vascular perforation and hemorrhage. In such cases, too, the appearances may be very decep-

tive. Thus, Wagret's patient, after a physician had made attempts to propel the bone, "experienced entire relief, and said to his benefactor that he thanked him very much, and that he had saved his life." But a few days later this patient died of perforation of, and hemorrhage from, the descending aorta. (Poulet.)

The first hemorrhage, in these cases, generally does not cause death; it ceases, for the time being, and the patients merely remain in a state of extreme weakness. Surgeons have been struck by this intermittence of the hemorrhage, and have endeavored to explain the manner in which a vessel as large as the thoracic aorta may cease to bleed after its walls are perforated. Shetter attributes the intermittence to two causes: 1, a temporary occlusion of the opening in the artery; 2, the weakness of the cardiac contractions. The process is a natural hæmostasis, like that described by Valsalva. The blood, being pushed with less force by the weakened heart, and being changed in composition, is in a condition the most favorable for forming obstructive clots. But when the heart recovers its energy, and the condition of collapse gives place to commencing reaction, the clot is displaced, and the hemorrhage reappears. The interval between the hemorrhages is usually not considerable, varying from a few hours to a few days. In some cases, especially when the perforation is small and is situated low down, all the blood extravasated flows into the stomach and thence passes into the intestines. The patient then suddenly presents, in the midst of perfect health, all the symptoms of an internal hemorrhage, whose explanation is very difficult. In one case this internal hemorrhage was manifested by some colicky pains, as the only subjective symptom. It is hardly necessary to add that all the remedial measures thus far tried have proved fruitless.[1]

Wounds of the Innominate.—During the late civil war, two cases in which the innominate artery was wounded came under treatment. The first patient survived twenty-four days, as follows:—

A soldier, aged 20, was wounded July 1, 1863, by a rifle-ball, which entered above the clavicle, passed behind the sternum, and emerged between the fourth and fifth ribs. On the 22d, hemorrhage from the arteria innominata occurred, for which compression was applied. Death followed on the 25th.[2]

It is highly probable that in this case the missile contused the tunics of the innominate artery, and that the bruised tissue exulcerated or separated as a slough at the end of three weeks, whereby the canal of the artery was opened, thus allowing a secondary hemorrhage to ensue.

The second patient lived six days after the casualty, as follows:—

A soldier, aged 26, was wounded October 27, 1864, by a conoidal ball, which entered at the right upper angle of the sternum, passed behind the clavicle, and lodged in the thorax. The wound was plugged with lint, and the man was kept as quiet as possible. On the 31st, under choloroform, the wound was explored for the ball, which caused profuse hemorrhage. Plugging the wound, with the use of a compress and bandage, was the only resource. On November 1, the patient had much dyspnœa, caused by hæmothorax. The trachea was compressed by blood extravasated in the mediastinum. On the 2d he died. *Necroscopy*—The missile was found resting against the innominate artery, whose canal it had opened, causing a diffused aneurism. The aperture was oval, nearly half an inch in length, situated on the front part of the vessel, just below its bifurcation.[3]

By exploring the wound with a finger, in this case, the surgeon might have detected the orifice in the innominate artery, and by covering the

[1] Ibid., p. 94.
[2] Medical and Surgical History of the War of the Rebellion, First Surg. Vol., p. 520.
[3] Ibid., pp. 520, 521.

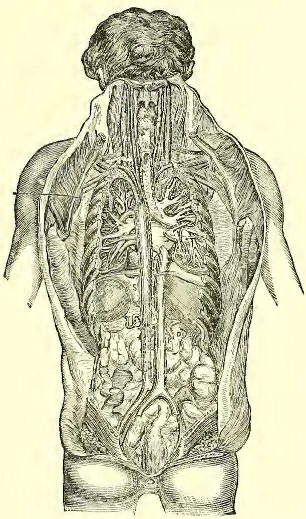
orifice with this finger in the wound, he might have restrained the hemorrhage until the artery had been exposed and ligatured on each side of the aperture. The proceeding here recommended is exactly that which has many times been practised with complete success in wounds of the femoral and carotid arteries.

WOUNDS OF THE SUBCLAVIAN ARTERY.—The traumatic lesions of this artery are not always hopeless. During the late civil war, at least five cases required surgical treatment, and in one of them the left subclavian was successfully ligatured by a Confederate surgeon. The others survived the casualty from two to sixteen days.[1]

In cases belonging to this category, the hemorrhage should, if possible, be restrained by digital compression, applied in the way just pointed out, until the artery can be tied above and below with carbolized catgut.

WOUNDS OF THE VENÆ CAVÆ.—In this class of injuries, death usually occurs so speedily from hemorrhage that examples of them are but rarely seen by surgeons during life. I will present a few illustrative cases:—

Fig. 430.



Showing from behind the relations of the aorta, venæ cavæ, heart. pulmonary artery and veins, etc., to the other viscera.

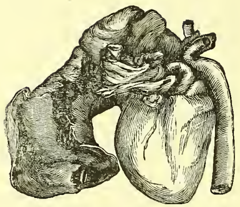
During the late eivil war, a soldier reeeived a shot-wound through the chest; "a great stream of blood is said to have gushed from his mouth as he fell forward, dead." *Necroscopy*—The ball entered at the right edge of the sternum, between the first and seeond ribs; pierced the *descending cava*, one ineh above the heart; struck the right bronehus, severing three rings (thus giving a ready exit to the large stream of blood); and emerged between the seventh and eighth ribs without wounding the lungs. There was a little elotted blood in the mediastinum under the sternum.[2]

In another case, death ensued not quite so rapidly:—

A soldier during the late eivil war, through the stock of whose musket a eonoidal ball had passed, was fatally wounded thereby. The missile entered his chest through the second right intereostal spaee, divided the *descending cava*, erossed the ehest diagonally beneath the aorta, emerged through the third left intereostal spaee, shattered the left humerus, and was found thirteen feet from where the man fell, in a battered state. Externally there was seareely any hemorrhage; but the left pleural cavity eontained mueh bloody serum mixed with jelly-like elots. The hemorrhage was exelusively due to the division of the eava. The patient lived long enough to be earried from his post to the hospital, near by, where he immediately died. The missile also perforated the superior lobe of the left lung. The speeimen is preserved in

[1] Medical and Surgical History, etc., First Surgical Vol., p. 521.
[2] Ibid., p. 520.

Fig. 431.



Shot-wound dividing the descending cava and perforating the left lung Heart and great vessels also represented.

the Army Medical Museum, and is represented in the accompanying wood-cut, Fig. 431.[1]

In the following example, the patient survived still longer:—

A soldier was wounded with arrows, and scalped by Indians, six miles from Fort Philip Kearney, D. T., September 26, 1866. The steel point of one arrow entered at the junction of the first (right) rib and the sternum, and penetrated downward and inward three inches, cutting the upper margin of the right lung, and making a wound in the *descending cava* one-eighth of an inch long, just without the pericardial sac. Although scalped, and otherwise wounded, the unfortunate man survived until 10 A. M. on the 28th, over forty hours after the casualty. Large masses of coagula were found in the thoracic cavity.[2]

Wounds of the *ascending vena cava*, as a rule, also prove quickly fatal:—

A soldier, during the late civil war, was wounded February 24, 1862, and lived only a few minutes. The ball entered the right side of his thorax, fracturing the ninth rib near its angle, and wounding the lower border of the right lung. It then passed through the diaphragm, tearing open the liver, the ascending cava, the stomach, etc. etc. The heart was found empty, while the cavities of the abdomen and thorax were entirely filled by the hemorrhage.[3]

The ascending cava sometimes sustains a rupture from the operation of a comparatively trivial cause: Dr. Minor presented an illustrative specimen to the New York Pathological Society, November 28, 1855. It was taken from a woman in the fifth month of pregnancy, who, while dancing at a ball, suddenly fell to the floor and died.[4]

There are on record a few examples in which the abdominal bloodvessels were ruptured. Legouest's case I have already presented. Velpeau[5] refers to three cases of rupture of the ascending cava. Bourguignon[6] cites another such case. A specimen of the vena cava ruptured by a blow is preserved in Guy's Hospital Museum. Professor Gross mentions a fatal case of laceration of the splenic vein recorded by Dr. Miling.[7]

Wounds of the Vena Azygos.—Hennen[8] reports the case of a soldier injured by a twenty-four pound shot, which brushed along the right pectoral muscles without raising the skin or fracturing any bone, who died thirty-six hours afterward with all the symptoms of suffocation. *Necroscopy*—The vena azygos was found ruptured; also, the intercostal artery accompanying the fourth right rib; and two pounds of blood were found extravasated in the thoracic cavity. Blandin[9] observed the case of a young man who survived a short time a pistol-shot wound of the vena azygos, near its terminal curve. Breschet[10] records the autopsy of a man, aged 25, who survived for

[1] Specimen 5567, Sect. I., A. M. M.; Circular No. 3, S. G. O., 1871, p. 34.
[2] Circular No. 3, S. G. O., p. 146.
[3] Medical and Surgical History, etc., Second Surgical Vol., pp. 138, 139.
[4] Transactions of New York Pathological Society, vol. i. p. 99.
[5] Dict. de Méd., etc., t. i. [6] Bull. de la Soc. Anat., t. xiii. p. 507.
[7] System of Surgery, 5th ed., vol. ii. p. 687.
[8] Military Surgery, p. 95, Am. ed.
[9] Anatomie Topographique, p. 287.
[10] Repertoire Gén. d'Anat., etc., t. iv. p. 196.

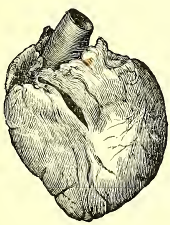
three days a punctured wound, received in a duel, of the azygos vein in the curve it describes before entering the cava.[1]

Wounds of the Pericardium.—The examples of this lesion which were reported during the late civil war tend to confirm the conclusions of Fischer—derived from the analysis of 51 cases with 22 recoveries—that wounds of this membrane, unless gravely complicated, are not as dangerous as has generally been supposed.[2] Two specimens preserved in the Army Medical Museum illustrate the subject, viz.: Specimen 504, a conoidal musket-ball imbedded between the arteria innominata and the descending cava within the pericardium, provoking pericarditis;[3] and Specimen 2243, exhibiting shaggy deposits of lymph on the heart and pericardium, following gunshot injury.[4] Eight cases with three recoveries are recorded with considerable minuteness of detail in the first surgical volume of the "History of the War" (pp. 528, 529).

Wounds of the Heart.—The traumatic lesions of the heart, though justly ranked among the most dangerous of all injuries, are not in every instance mortal.

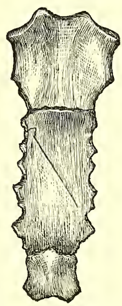
A man was killed[5] in an affray at Fort Dodge June 2, 1867. He had inflicted, with a large sheath knife, several stabs upon his antagonist, when the latter, seizing his wrist, turned the point of the knife toward him, and suddenly drove the blade with great force into his chest, the handle being still grasped in his own hand. He fell at

Fig. 432.



The heart, showing the incised wound of the right auricle. (Spec. 4870, sec. 1, A. M. M.)

Fig. 433.



The sternum, showing an oblique incision through it, which penetrated the right auricle of the heart. (Spec. 4869, sec. 1, A. M. M.)

once, gasping for breath, with his face deadly pale, and expired in about eight minutes. *Autopsy*—The knife-blade, after cutting cleanly through the sternum, had traversed the mediastinum, and freely opened the right auricle of the heart. The pericardium and the mediastinum were filled with extravasated blood, and the cardiac cavities were empty. The specimens are represented in the accompanying wood-cuts (Figs. 432 and 433).

[1] See Medical and Surgical History, etc., First Surgical Vol., p. 527. Foot-note.
[2] Ibid., p. 528. [3] Catalogue, p. 453. [4] Catalogue, p. 454.
[5] Medical and Surgical History of the War of the Rebellion, First Surg. Vol., p. 534; Circular No. 3, S. G. O., 1871, p. 91.

The traumatic lesions of the heart consist of punctured and incised wounds; contusions, lacerations, and ruptures; and gunshot wounds. Formerly, punctured and incised wounds were most frequently met with; at present, however, the lesions from firearms are much more common. Of twenty cases which occurred in our army during a period of five years after the civil war, the patients in eighteen were wounded by firearms, and in two were stabbed with knives.

Death occurs instantaneously in some of the cases. But, in most instances, a brief interval elapses before life is extinguished. When severe blows on the chest from falls, or from the kicks of animals, or from spent shot or large fragments of shells, rupture the heart without external wound, death almost always occurs on the spot. M. Terrillon, however, in an article on traumatic rupture of the heart, has presented a case in which the heart was ruptured by a fall, and the patient lived four hours; also the case of a man whose heart was ruptured from being kicked in the chest by a horse, and knocked backward, who was able to get up, put on his hat, and walk toward the stable, falling dead on the way.[1]

When, too, the heart is wounded by firearms, death does not always immediately follow. In the surgical history of the late civil war, four cases of this sort are recorded. In one of them the patient lived one hour and a quarter after a perforation of the right auricle and left ventricle by a conical pistol-ball; in another, the patient lived forty-six hours after a perforation of the left auricle and left ventricle by a pistol-ball, although the case was complicated by wounds of the abdomen and axilla; in still another instance the patient survived, for fourteen days, a wound of the right auricle made by a round musket-ball; and in the fourth example, the patient survived, for two and a half years, a gunshot wound of the right auricle.

This patient was a sharp-shooter, aged 42, who was wounded at Spottsylvania May 12, 1864, by a conoidal musket-ball, which entered his left breast and emerged from his left shoulder, passing completely through the left thorax, injuring the heart and left lung. On November 22, 1866, he very suddenly died. At the *autopsy*, the evidence of the original injury of the heart was found. On tracing the track of the ball a cicatrix was distinctly seen on the right auricle; softening and rupture of the muscular tissue of the auricle had resulted, with almost instantaneous death.[2]

An important specimen illustrating a pistol-shot wound passing through the pericardium, the right ventricle, and the septum, together with the semilunar valve next the septum, into the aorta, with apparent recovery, was shown to the New York Pathological Society:[3]—

A farm-hand, aged 18, was accidentally shot in the left breast July 7, 1878, with a small revolver (calibre $\frac{22}{100}$ inch). In less than a fortnight he was again at work, apparently well. He continued in good health, performing the ordinary labor of a farm-hand without inconvenience, until August 30, when he was found dead at his work behind a plough, fifty-four days after the accident. The *autopsy* showed that death had resulted from extravasation of blood into the pericardium and left pleura. The missile was found in the left ventricle, lying behind a columna carnea. The track of the ball was found to be as stated above. The explanation of the lodgment of the ball is, that it encountered a well-filled left auricle, and, being spent, it dropped down through the left auriculo-ventricular opening to the place where it was found. The wound through the right ventricle was valvular, and the pericardium, healing quickly here, prevented the escape of blood. This finally rupturing, from over-distension, death ensued. With

[1] Le Progrès Médical, Mars 29 et Avril 5, 1879; also American Journal of the Medical Sciences, October, 1879, pp. 566, 567.
[2] Medical and Surgical History of the War of the Rebellion, First Surg. Vol., pp. 530, 531.
[3] Medical Record, December 14, 1878.

needful rest for a time, instead of labor, no reason appears why this young man should not have in reality recovered.

Velpeau mentions the history of a man who was stabbed in the left side. The symptoms which ensued were such that at the time the heart was supposed to have been pierced. Nine years afterward he died from other causes. The *autopsy* established the truth of the former diagnosis, as the cicatrix of the wound was found in the right auricle as well as in the pericardium.[1]

Dr. George Fischer[2] has collected 452 cases of heart-wound, of which 380 ended in death, and 72 in recovery. Death was immediate in 104 cases, while in 270 it occurred after intervals varying from one hour to nine months. There were 44 punctured wounds with 10 recoveries; 260 punctured and incised wounds with 43 recoveries; 72 gunshot wounds with 12 recoveries; 76 contusions and traumatic ruptures with 7 recoveries. In 36, or exactly one-half of the 72 recoveries, the diagnoses were verified by post-mortem examinations held long after the original injuries; and this circumstance affords good ground for supposing that the remaining 36 cases were likewise correctly diagnosed. Fischer also notes the relative frequency with which different parts of the heart were wounded. In 123 cases it was the right ventricle; in 101, the left ventricle; in 28, the right auricle; in 13, the left auricle; and in 17, the apex of the organ. The right ventricle and the right auricle are wounded much oftener than the left ventricle and the left auricle, because they occupy by far the larger share of the front or the exposed portion of the heart; the statistics collected by M. Ollivier and by M. Jamain support Fischer's conclusions.

Additional examples of *recovery* from wounds of the heart, which have appeared during the last twelve years, may be found reported as follows:—

In the London Lancet[3] a case is recorded of the removal of a needle from the heart on the ninth day, recovery ensuing. Dr. C. L. Ford[4] reports a case of heart-wound from buck-shot, which was successfully treated. In the British and Foreign Medico-Chirurgical Review[5] there is related a case of bullet-wound of the heart with recovery; on the twentieth day the external wound was already healed, and the cicatrix moved synchronously with the systole of the heart.

Additional examples of *long survival* after wounds of the heart, which have been noted during the last twelve years, may be found reported as follows:—

Mr. West,[6] in an article on wounds of the heart, gives a summary of twenty cases. In one of them, the patient lived 19 years and 7 months after both ventricles had been wounded with a knife. Dr. P. S. Conner[7] reports a case of gunshot wound of the heart, wherein both ventricles and the right auricle were involved, and yet the patient survived 3 years, 2 months and 13 days. Steudener,[8] of Halle, is quoted as reporting a case of pistol-shot wound of the heart, with survival for 15 weeks. On autopsy, a cicatrix was found at the apex of the left ventricle, corresponding to the wound of the pericardium; grains of powder were also found embedded in the substance of the heart. Sir James Fayrer[9] mentions a case of bullet-wound of the heart, with survival for 72 days. The missile was found in the apex of the left ventricle. Tillaux is quoted[10] as having exhibited at the Société de Chirurgie, the heart of a woman who had survived two gunshot wounds for 18 days, one missile lodging in the left ventricle of the heart. Dr. H. W. Boone[11] relates a case of gunshot heart-wound, with survival for 13 days. A case of stab-wound of the right ventricle of the heart is reported, in which the patient

[1] Traité d'Anat. Chirurg., t. i. p. 604, 2e éd.
[2] Archiv f. klin. Chir., Bd. ix. H. 2, S. 571. Berlin, 1868.
[3] Lancet, 1873, vol. i. p. 272.
[4] Medical Record, 1875, p. 173.
[5] No. for July, 1876, p. 205.
[6] St. Thomas's Hospital Reports, 1870, p. 237.
[7] St. Louis Clinical Record, 1876.
[8] London Medical Record, 1874, p. 212.
[9] Lancet, 1879, vol. i. 658.
[10] Canada Lancet, 1876, p. 242.
[11] American Journal Med. Sciences, October, 1879, p. 509.

lived 5 days.[1] Dr. G. F. Dudley[2] reports a case of pistol-ball in the heart, in which the patient lived 4 days.

*Symptoms of Heart Wounds.*—These are often very obscure. There may be present, in cases of wound which penetrate the region of the heart, great prostration of strength with swooning or syncope, a thready, weak, irregular pulse, a feeble and tumultuous action of the heart, precordial distress and anxiety, with dyspnœa and other signs of hemorrhage into the pericardial and pleural sacs, pallor, cold sweats, a husky voice and excessive thirst, together with a systolic bellows murmur or other abnormal sounds, without establishing anything more than a strong presumption that the heart itself is wounded. But, although the traumatic lesions of the heart are not attended by any symptoms that are peculiar to, or characteristic of them, the concurrence or coincidence of most of the phenomena just mentioned, in a case where the patient is wounded in the cardiac region, will render the diagnosis of a cardiac wound highly probable. According to Dr. Fischer's statistics, the phenomena which usually predominate in cases of sudden death from this lesion are those of sudden syncope or collapse; not unfrequently a hurried exclamation or a convulsive gasping occurs; but the popular notion that persons spring into the air when shot or stabbed through the heart, is not supported by the facts.

In the *causation of sudden death* from traumatic lesions of the heart, there are three important factors: (1) Shock; (2) Anæmia of the brain and lungs, directly caused by the escape of blood from the chambers of the heart: (3) Arrest of the cardiac movement by compression resulting from distension of the pericardium with extravasated blood. Oftentimes, in such cases, a *necroscopy* shows the heart firmly contracted and empty, with much extravasation of blood in the pericardial and pleural sacs.

*Traumatic carditis* is a very infrequent complication, if, indeed, it ever does occur. During the late civil war, enough examples of cardiac wounds in which the fatal issue was sufficiently delayed to afford time for the development of inflammatory phenomena, were observed, to warrant the conclusion that inflammation of the heart is as infrequently the result of injury, as of disease. The late Dr. Otis carefully examined two specimens from patients who had survived, for a fortnight or more, shot wounds grazing the heart, in which the pericardium was thickened, and the visceral as well as the reflected layer of the pericardium thickly coated with shaggy exudations; but the muscular structure presented no alterations discernible by the microscope.[3] Professor Gross is possessed of a pericardium, taken from a man, aged 22, which contains an encysted needle two inches in length, giving evidence of having been long a harmless intruder. This specimen illustrates the indisposition of the parts to take on inflammatory action.

*Treatment.*—At first, the posture of the patient must be recumbent, with the head low, in order to avoid a fatal syncope from cerebral anæmia. External warmth should be applied to the extremities and along the spine. Opium or morphia should be administered to quiet alarm and restlessness, as well as to allay pain. In many cases the surgeon's hope must rest upon the continuance for some time of a condition approaching collapse, by which the power of the heart will be greatly lessened and the stability of a clot more assured. If signs of a dangerous reaction appear, the tincture of veratrum viride should be employed to restrain the heart's action (Agnew). Should life be prolonged, and inflammatory phenomena arise, reliance must be placed on blisters, opium, and cardiac sedatives; and should distension of the peri-

[1] St. Thomas's Hospital Reports, 1874, p. 420. [2] Medical Record, 1871–2, p. 156.
[3] Med. and Surg. History, etc., First Surg. Vol., p. 622.

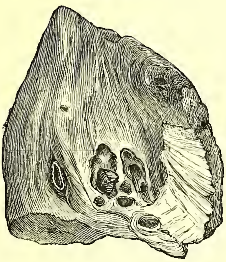
cardial sac with inflammatory products cause much dyspnœa or cardiac embarrassment, they must be withdrawn by paracentesis. Absolute quietude of body and mind must be maintained for a long time, with liquid alimentation in concentrated and easily digestible forms.

Wounds of the Pulmonary Artery.—Traumatic lesions of this vessel almost always prove quickly fatal. But Timaeus of Colberg records the case of a nobleman, stabbed through the right axilla, between the third and fourth ribs, the blade wounding the pulmonary artery. Frothy blood flowed externally, and there were frequent syncopes; still the wounded man lived three days.[1]

Wounds of the Pulmonary Veins.—In the first surgical volume of the history of our civil war, at page 588, is recorded a case in which a conoidal ball penetrated the left chest, and lodged, on October 27, 1864:—

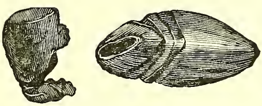
The patient suffered much from dyspnœa and frequent painful cough. He steadily grew worse, and died on November 11 of secondary hemorrhage from the left pulmonary vein. *Autopsy*—The missile, as shown in the accompanying wood-cuts (Figs. 434 and 435), was found lodged against the left pulmonary vein, which had been opened by it.

Fig. 434.



Showing the upper half of left lung with a conoidal ball embedded in its substance, and partially occluding the left pulmonary vein. (Spec. 3388, sec. I, A. M. M.)

Fig. 435.



Showing the ball and a piece of lead removed from Spec. 3388.

Dr. Otis refers to Specimen 3388, A. M. M., represented above (Fig. 434), as suggesting a possible explanation of the way in which balls and other foreign bodies may gain admission to the cavities of the heart without leaving any trace of wound in the walls of that organ, viz., by gradual absorption of the wall of the pulmonary vein compressed by the extraneous body.[2] In the above case, the missile probably contused the tunics of the pulmonary vein, and thus laid the foundation for secondary hemorrhage to occur when the bruised tissue should separate by ulceration, and open the vessel.

## Wounds of the Middle Meningeal Artery.

This vessel, from its peculiar position and wide distribution, is much exposed to injury in simple as well as in compound fractures of the skull, and in the

[1] Ibid., p. 527. Foot-note.

[2] Ibid., p. 613.

common accidents of civil life as well as in the casualties produced by fire-arms and sabre-cuts in time of war. Furthermore, from the situation of this vessel and its branches in bony canals on the inner surface of the skull, there results, when it is torn across or severed, that the ends are held open by the surrounding structures, and that their expanded mouths cannot contract or retract; and for this reason spontaneous hæmostasis does not occur here, as it usually does in other parts of the body when arteries of a similar calibre are lacerated. Therefore, when the middle meningeal artery is wounded, the extravasated blood, if it cannot escape externally, collects between the dura mater and the bone, and compresses the brain; and the extravasation continues to go on, and the compression of the brain continually increases, until life is extinguished thereby. This is the reason why wounds of this small artery, in cases where there is no external vent for the extravasated blood afforded by the accident itself, or by the surgeon's art, always prove fatal. This inability for spontaneous hæmostasis to occur, is also the reason why the hemorrhage from this small artery, when it flows into an open wound, is often so persistent, and so difficult to suppress, that it demands the application of a ligature to the wounded vessel itself, or to the parent trunk, in order to save the patient from death by anæmic exhaustion.

The *symptoms* which hemorrhage from this artery causes when the blood is imprisoned within the skull, I shall not recite, for they are the symptoms of cerebral compression, and will be found set forth in full in the article on Injuries of the Head. What I have here to say is that, in such cases, the artery must be laid bare where it is wounded, in order to arrest the hemorrhage and avert its consequences, by performing the operation of trephining; and that, without the timely performance of this operation, there is no hope for the patient. If the application of one crown of a trephine does not bring the injured vessel into view, by reason of the clot covering it, or from any other cause, the instrument must be again applied over the normal track of the artery, either alongside the first perforation, or at the anterior inferior angle of the parietal bone; the search must be continued until the bleeding vessel is found, and when that is done it must be ligatured with carbolized catgut. The coagula must also be removed, and the wound must be treated antiseptically. If the symptoms of compression follow the injury very quickly, the inference, in the absence of other indications, is that the artery is wounded near the point where it enters the skull, that is, near the anterior inferior angle of the parietal bone, and there the trephine should be applied.

The middle meningeal artery is sometimes torn in cases of slight fissure of the inner table of the skull, when the outer table is uninjured. Such a case is the following:[1]—

A boy, of strong, muscular build, was struck on the right temple by a cricket ball. The symptoms of cerebral compression ensued, and he died three and one-half hours after he received the blow. *Autopsy*—No bruise was found. On reflecting the scalp, however, a very scanty extravasation of blood was discovered under the right temporal aponeurosis. The external table of the skull was uninjured; but there was a slight crack which extended across the inner table. At this part, the middle meningeal artery ran in an osseous canal. A piece of bone was broken off, and the artery was torn completely across at this point. A clot, half the size of the fist, lay between the cranium and the dura mater, and the corresponding portion of the brain presented a distinctly bruised appearance.

The operation of trephining, seasonably performed, with antiseptic precautions and antiseptic after-treatment, would pretty certainly save such a patient;

[1] Edinburgh Medical Journal, vol. iii. p. 191.

and the case just related serves well to illustrate, in other respects, the soundness of the views above presented.

But compound fractures of the skull, especially when caused by fire-arms, are not unfrequently attended by *secondary hemorrhage from the middle meningeal artery*, which will prove fatal unless it is suppressed by the surgeon in a timely manner. What is the best plan of treatment?

In two cases of gunshot (shell) fracture of the skull involving also the middle meningeal artery, that were reported during the war of the Rebellion, in which the hemorrhage was uncontrollable by other means, it was permanently arrested by tying the common carotid artery. The following is a brief account of them:—

Private Wm. C. Andrews, Co. A, 30th Iowa Volunteers, aged 19, was wounded by a fragment of shell in the left temporal region, at Vicksburg, December 28, 1862. He was treated in a field hospital until January 17, 1863, when he was admitted to Lawson Hospital, St. Louis. On the 18th, hemorrhage amounting to twelve ounces occurred from the middle meningeal artery, and, all other means failing, was arrested by Dr. C. T. Alexander, U. S. Army, by tying the common carotid artery. The hemorrhage did not recur. The patient was discharged from the service on May 28. He was a pensioner in March, 1868, and the Pension Examiner reported that he had dizziness and faintness on exertion or stooping, and partial anæsthesia of the left side of the face, being compelled to keep his room in the cold winters of Madison, Iowa, from liability of the left ear and side of the face to be frozen. He continued in tolerable health on June 4, 1872, nearly ten years after the operation.[1]

Sergt. Joseph Dougherty, Co. B, 69th New York Vols., aged 23, sustained a fracture of the right parietal bone by a shell, at Spottsylvania, May 13, 1864. He was brought to hospital at Alexandria. A fragment of bone was removed. Hemorrhage from the middle meningeal artery occurred, of such a character as to compel Dr. E. Bentley, U. S. Vols., to ligate the common carotid artery. "The hemorrhage did not recur; but the patient succumbed on the thirteenth day, after a series of chills and other phenomena of pyæmic infection."[2]

When we are sure that the hemorrhage proceeds from the middle meningeal artery, we should ligature the external carotid, of which the middle meningeal is a branch, instead of the common carotid artery; for the ligation of the former is much less likely to be followed by cerebral softening and other bad consequences, *per se*, than the ligation of the latter, while it is quite as likely to control the bleeding.

In cases of secondary hemorrhage from the middle meningeal artery, as well as in those of primary hemorrhage, the bleeding vessel should, if possible, be ligatured by the surgeon where it is injured. But when it is not feasible to do that, as will not unfrequently happen, while the wound is suppurating, the external carotid should be tied. Moreover, the performance of the operation should not be delayed from any expectation that because the artery is a small one, the bleeding can be stanched by minor procedures. Should, unhappily, the operation be deferred while the trial of compression and styptics is continued in such cases, the hemorrhage will continually recur as soon as the patient rallies from each successive bleeding, until finally he will become so much exhausted from loss of blood that the successful ligation of the external carotid will be impossible.

## Wounds of the Abdominal and Pelvic Bloodvessels.

These wounds are extremely dangerous, and their great perilousness results from the hemorrhage—which usually is internal, and therefore concealed from

[1] Med. and Surg. Hist., etc., First Surg. Vol., p. 314. [2] Ibid., pp. 255, 256.

view—by which they are attended. The dictum of Jourdan, that surgery is powerless in lesions of arteries within the cranial, thoracic, and abdominal cavities, should be expunged, because it is not true. If the surgeon, with cautious temerity, explore a penetrating wound of the abdomen or pelvis with his finger, he will not unfrequently discover that a hemorrhage which threatens life proceeds from a vessel which he can ligature above and below the wound with carbolized catgut; and thus he may save his patient from an otherwise certain death.

Extravasation of blood into the peritoneal cavity may proceed from wounds of the abdominal aorta and its branches; or from wounds of the ascending vena cava and its tributaries; or from lesions of the vena portalis and its ramifications; or from lacerations of the viscera, especially the liver and spleen.

The sudden occurrence of a copious extravasation of blood into the abdominal cavity is indicated by the sudden appearance of the well-known constitutional signs of hemorrhage, even without any external bleeding, in cases where wounds penetrate the abdominal cavity or involve the organs contained in it. These signs are pallor of the face, and of the surface generally, from bloodlessness; faintness; smallness, quickness, and feebleness of the pulse; cold sweats, etc. A slow, gradual bleeding into the abdominal cavity may, however, continue unsuspected to a dangerous or even to a fatal extent, so slight are the symptoms caused by it. For instance, Follin mentions a case in which death resulted from the puncture of a terminal ramification of the mesenteric artery by a bayonet, and in which the hemorrhage was not suspected until revealed by the autopsy.

The hemorrhage from a ruptured liver or spleen should be treated by placing the patient on the injured side and enforcing absolute immobility, by applying ice-poultices over the injured organ, and by freely administering gallic acid, with ergot, and with dilute sulphuric acid, to assuage thirst. To allay pain and quiet apprehension, opium or morphia must be exhibited. The same plan of treatment should be applied to all the hemorrhages which occur into the abdominal cavity without external wound, to those from ruptured veins and arteries, as well as to those from ruptured viscera. Moreover, phlebotomy must be rejected in all of them.

But in cases where there is an external wound which penetrates the abdomen, the possibility of restraining the hemorrhage by ligaturing the injured vessel must always be considered. It is a disgrace to modern surgery that patients should be allowed to die of internal hemorrhage, in cases of wounds penetrating the abdominal cavity from the front or the sides, without any effort being made to save them by cautiously exploring the wound with a finger, ascertaining through the sense of touch the source of the hemorrhage, and securing the bleeding vessel with carbolized catgut ligatures. Sometimes the blood flows inwardly into the peritoneal cavity, from a wounded artery belonging to the abdominal walls, such as the internal epigastric, instead of escaping externally. In such a case, the exploration of the wound with a finger may instantly reveal the source of the bleeding. And then the surgeon can make his patient secure without delay, by enlarging the wound so as to bring the injured vessel into view, and tying it on each side of the aperture with carbolized catgut. I have already dwelt upon the disastrous consequences of neglecting this paramount procedure. I also believe that operative interference should be carried in this direction to the utmost verge of the limits which prudence enjoins. Examples are not wanting in which branches of the mesenteric, epiploic, gastric, and colic arteries, have been successfully ligatured. If the finger, introduced into a wound penetrating the belly, recognizes the warm jet of a bleeding artery, the bleeding point must be exposed and securely tied. It would be more rational to ligature even the

vena cava or the aorta, than to stuff the wound with lint saturated with Monsel's solution, as has been done in more than one mortal hemorrhage. (Otis.)

When, therefore, the abdomen has been penetrated by a wound, and considerable bleeding takes place, it is necessary to search for the injured vessel. When it comes from one of the mesenteric arteries or from the epigastric, the wound should be enlarged until the bleeding artery is exposed, and then ligatures should be placed on both ends. (Guthrie.) To the dictum of Guthrie just presented, I would add that the vessel from which the deadly hemorrhage is issuing, whatever its name and rank may be, must be found, and ligatured above and below, if possible. Effusions of blood into the abdominal cavity which do not directly kill by syncope, may do so indirectly. When the quantity is large, the blood fails to become absorbed; it then decomposes, and causes death by inducing septicæmia or by exciting peritonitis. In penetrating wounds, therefore, after the hemorrhage has been suppressed by ligature, the extravasated blood should be evacuated as completely as possible, and antiseptic precautions should be employed.

Wounds of the *pelvic* bloodvessels have been but little studied. In civil as well as in military practice, the cases belonging to this group will sometimes present the most difficult as well as the gravest problems to the surgeon.

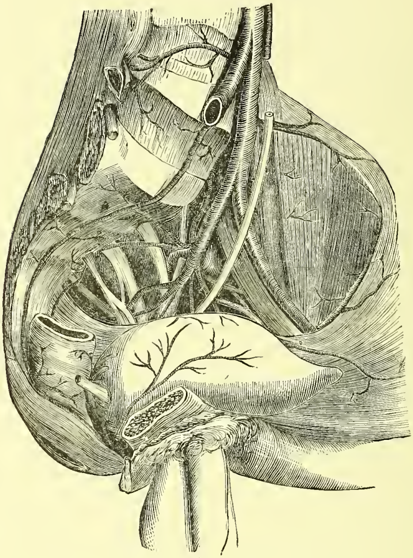
Wounds of the Common Iliac Artery.—The first ligation of the common iliac artery, it will be remembered, was performed by Gibson, to suppress the hemorrhage from a shot-wound. Our Army Medical Museum contains a specimen in which the right common iliac artery is perforated by a pistol-ball. A wood-cut illustrating this specimen has already been presented. (Fig. 296, Vol. II., p. 198.) The patient survived the casualty twelve minutes; and had a competent surgeon been at hand, the injured vessel might have been successfully tied on each side of the perforation, the main trunk meanwhile being firmly compressed, and the distal ligature first applied. Bogros, in Velpeau's presence, dissected a subject with a similar wound. Larrey[1] records a case of sword-puncture of the iliac vein and artery, treated apparently with success by provisional compression and the method of Valsalva. Such instances, however, are rare; but wounds of the branches of these vessels—of the gluteal, pudic, obturator, and sciatic arteries—often come under treatment, and their management requires the utmost discrimination.[2]

During the late civil war, hemorrhage was the most important complication in numerous cases of wounds penetrating the pelvis, and in many of them the precise source of the bleeding was not determined. It was not always decided even whether the bleeding vessels were branches of the external or of the internal iliac. In no region, too, was the application of the cardinal rule of ligaturing a wounded vessel above and below the lesion more difficult, and in none were the consequences of neglecting this rule more disastrous.[3]

Wounds of the Internal Iliac Artery.—The primary lesions of this vessel, like those of the common iliac artery, but seldom receive surgical treatment, because death from hemorrhage too speedily ensues. A case, however, is reported in the history of the late civil war, in which this artery appears to have been wounded by a musket-ball, and the man was taken to a field-hospital, where he died from internal hemorrhage fifteen hours after

[1] Clinique Chirurgicale, 1829, t. iii. p. 156.
[2] Medical and Surgical History of the War of the Rebellion, Second Surg. Vol., p. 323.
[3] Ibid., p. 325.

Fig. 436.



Showing the bloodvessels, nerves, and viscera of the pelvis.

the casualty.[1] Moreover, there are six cases of gunshot wound of the pelvis reported, in which *secondary hemorrhage* occurred from lesions of the internal iliac artery, between the twelfth and twenty-first days, and death ensued.[2] The tunics of the artery in each instance were probably bruised by the missile, and when the disintegrated tissue was separated from the sound tissue by ulceration, the artery was opened, and hemorrhage ensued. In three cases the internal iliac artery was ligatured on Hunter's plan to suppress the hemorrhage from a wounded branch, but without success in every instance.[3]

In the following case, the inferior hemorrhoidal arteries were wounded by a conoidal musket-ball, and death took place from secondary hemorrhage on the fortieth day:—

A soldier, aged 20, wounded May 8, 1862, in the buttocks and rectum, had hemorrhages several times which were checked by liquor ferri persulph. and opium, until June 16, when hemorrhage again occurred from the bowel, and he died in half an hour. *Necroscopy*—The ball entered the pelvis at the obturator foramen, passed directly through the rectum, broke off the spinous process of the ischium of the opposite side, and lodged in the fibres of the gluteus medius. The bleeding vessel was one of the inferior hemorrhoidal arteries; the space between the sacrum and rectum was filled with coagula; the recto-vesical fold was elevated, and its peritoneal surface was dark in color.[4]

[1] Ibid., p. 331.
[2] Ibid., pp. 330, 331.
[3] Ibid., pp. 332, 334.
[4] Ibid., p. 326.

Wounds of the Iliac Veins.—A few cases were reported during the late civil war in which traumatic lesions of the pelvic veins were the most important complications. Wounds which open widely the common iliac vein or its two principal tributaries, as a rule, prove quickly mortal from the primary bleeding. There is, however, a case recorded, in which a conoidal musket-ball penetrated the pelvis through the right ischiatic notch, and divided the corresponding internal iliac vein, the man surviving more than twenty-four hours. On opening the abdominal cavity after death, it was found to be full of blood.[1] In cases where the external iliac vein is wounded, or the femoral vein near its entrance into the pelvic cavity, should the primary hemorrhage be suppressed, gangrene of the corresponding extremity does not of necessity ensue, as I have already shown in the section on wounds of veins.

The *symptoms* resulting from an intra-pelvic extravasation of blood, when the quantity is small or but moderate, may be obscure or almost wanting. Baudens, however, mentions, as a characteristic sign that a quantity of blood is being collected in the pelvis, the incessant and insupportable desire to micturate, which is caused by the pressure that is exerted on the bladder by the extravasation, and which is present although there is no urine in the viscus.

In some cases, important aid in diagnosing the lesions of the pelvic blood-vessels may be obtained by introducing the hand into the rectum, as has been practised in two instances by Professor H. B. Sands, of New York.[2] By manual exploration with the hand in the rectum, the condition of the lower part of the abdominal aorta, and of the common, internal, and external iliac arteries, can be satisfactorily ascertained. By the same means pressure can be directly applied to the common iliac artery as well as to the external and internal iliacs, so as to readily control the flow of blood through them, as Dr. Woodbury had already shown.[3] The bowel should be evacuated by a large enema of warm water. The hand anointed with lard, and the fingers folded into a cone (the patient being anæsthetized), is gradually introduced into the rectum with its dorsum toward the sacrum, till it reaches the sigmoid flexure, when the hand may be pronated, and, as the vessels are directly under the fingers, they may then be examined or compressed at will. The sphincter recovers its tone in a few days, and, if the hand be slowly introduced, laceration is not apt to follow.

To suppress hemorrhage from the *external iliac vein*, when wounded, it will generally be necessary, as in cases where the femoral vein is wounded, to ligature the corresponding common femoral artery.

The mode of applying instrumental compression to the abdominal aorta, or the primitive iliacs, with Lister's or Erichsen's artery compressor, or Skey's or Pancoast's abdominal tourniquet, I have already pointed out (pp. 74, 127). Operative procedures should be pushed to the utmost bound of prudence when the pelvic arteries are wounded. In cases where gunshot missiles penetrate the pelvis, the liability to the occurrence of secondary hemorrhage from contusion of the internal iliac artery, or its branches, should always be remembered, and provided for as far as possible.

The timely application of instrumental pressure to the common iliac artery, together with the enforcement of absolute immobility of the patient, in cases of hemorrhage (whether primary or secondary) from wounds penetrating the pelvis, where ligatures cannot be applied, may possibly so restrain the bleeding that an occluding clot of a permanent character will plug the orifice, or that, at least, a traumatic aneurism amenable to treatment may result.

[1] Ibid., p. 190. [2] Am. Journ. Med. Sciences, April, 1881, pp. 366–373.
[3] Ibid., January, 1874.

## Traumatic Aneurism.

Definition.—A traumatic aneurism is a tumor filled with blood poured out from, and communicating with, the canal of a wounded artery. Between traumatic and spontaneous aneurisms there is another important distinction: namely, that in the former there usually exists before the accident a sound condition of the injured vessel, whereas, in the latter, the arterial tunics are diseased.

Etiology.—Traumatic aneurisms are caused by punctured, contused, lacerated, gunshot, and incised wounds of arteries, and I have already presented many examples of them in the foregoing pages, while discussing the several kinds of arterial wound.

Varieties.—Of traumatic aneurisms, two varieties are recognized: (1) the *diffused;* (2) the *circumscribed.* Each variety may, and often does, exist without an external wound.

I. Diffused Traumatic Aneurism.—The *diffused* variety occurs immediately after the puncture, rupture, or division of an artery when there is no external wound; or, if there is an external wound, when it is valvular, or perchance closed in some other way, so that the blood cannot outwardly escape. Thus, the *diffused* variety of traumatic aneurism consists of an extravasation of blood into the connective tissue of the part. It is, in reality, not an aneurism at all, but a wounded artery with internal or concealed hemorrhage, instead of external bleeding. The tendency of a diffused aneurism is to constantly extend itself, or to expand by stretching and separating the anatomical components of the part wherein it is situated, and filling the space with soft coagula, until it bursts open from the mechanical distension of the part; or until inflammation, abscess, or sloughing takes place, when, an external opening being formed, the patient will perish from hemorrhage, unless the surgeon by timely interference stop the bleeding. If left to themselves, these tumors never undergo spontaneous cure.

*Symptoms.*—The diffused variety of traumatic aneurism is a subcutaneous, soft, and fluctuating tumor, often of considerable size, containing extravasated blood, and rising up or appearing immediately or very soon after the wounding of an artery. At first the skin covering it is not affected; but in a few days it frequently becomes discolored with ecchymoses, caused by the infiltration of blood. If the aperture in the artery be large and free, the tumor will exhibit pulsation, synchronous with the heart-beat, accompanied by a thrilling, purring, or jarring sensation, and often by a loud bruit. If, however, the injured artery be small, or if the aperture in the arterial tunics be oblique, or of a limited size, or obstructed, there will be no distinct pulsation or bruit; in such cases, the tumor will be indolent and semi-fluctuating, or will, perhaps, exhibit an impulse which is communicated to it by the subjacent artery. In the section on lacerated wounds and ruptures of arteries, I have presented many examples of diffused traumatic aneurism in which there was neither pulsation, nor thrill, nor bruit. The size of an aneurism of this variety will, in great measure, be determined by its locality. For instance, in the armpit, where the subcutaneous connective tissue is very loose, or at the root of the neck, or in the thigh, it may rapidly attain a very great bulk; whereas, in the palm of the hand, or at the bend of the elbow, in consequence of the strength and resistance of the fasciæ, its growth is correspondingly restricted. When the blood is suddenly effused in great quantity,

in a traumatic aneurism of the axillary or femoral region, all the constitutional signs of hemorrhage—pallor, cold sweating, pulselessness, and syncope—may arise; and sometimes, in such cases, death from anæmic exhaustion, as well as from syncope, may ensue. Of this I have already presented a number of illustrative cases.

*Treatment.*—Diffused traumatic aneurisms require the same treatment as wounded arteries, which has already been minutely set forth in the foregoing pages. Erichsen well observes:—

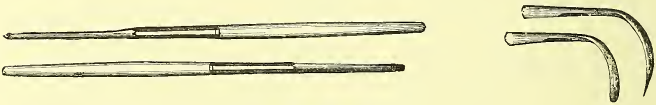
> The treatment of these cases must be conducted on precisely the same plan as that of an injured artery communicating with an external wound, the only difference being, that, in the case of the diffused traumatic aneurism, the aperture in the artery opens into an extravasation of blood, instead of upon the surface. We must especially be upon our guard not to be led away by the term *aneurism* that has been applied to these cases, and not to treat such a condition, resulting from wound, by the means that we employ with success in the management of that disease.[1]

The safety of the patient generally depends upon exposing the injured artery, and ligaturing it above and below the lesion. In deeply-seated arteries, *e. g.*, the gluteal in the buttock, or the posterior tibial in the calf of the leg, this is not always an easy operation. In some cases, however, compression with absolute quietude of the injured part should be tried before resorting to ligation. When arteries are ruptured by fragments of bone in simple fractures of the leg or thigh, compression, digital or instrumental, continuous or intermittent, should be applied to the main trunk of the femoral artery. This, together with the immobility of the injured limb and the moderate degree of pressure on the tumefaction which are furnished by the dressings of the fracture, has proved much more successful in such cases than any other plan of treatment, as I have already shown in the section on lacerated wounds and ruptures of arteries. So, too, in cases where the axillary artery is ruptured in reducing old dislocations, and a diffused aneurism forms in consequence thereof, compression should be applied to the subclavian artery over the first rib by means of a door-key, while the arm is immovably fastened to the chest by a roller, as I have already pointed out in the same section. Should compression fail in either class of cases, deligation of the main artery on the plan of Hunter will generally succeed, provided the arm be kept immovably fixed to the chest in one class of cases, or the leg be held motionless by the fracture dressings in the other. But, in cases where immobility of the injured part cannot be secured, the wounded artery should be laid bare and ligatured above and below the lesion, that is, the "old operation" for aneurism should be performed without delay. When an aneurism upon which the "old operation" is about to be performed is so situated that the circulation in the main artery cannot be controlled by digital compression, nor by a tourniquet, nor by Esmarch's elastic ligature—as, for example, at the root of the neck—the surgeon should commence the operation by making a puncture just large enough to admit one or two fingers of his left hand, which he should quickly thrust into the swelling in such a manner as to plug up the orifice in the integuments; with a finger he should then search the bottom of the cavity, and find the aperture in the wounded artery, be it primitive carotid or subclavian; and with a finger or fingers he should cover the aperture in the wounded artery so as to prevent any outflow of blood from it while he lays the tumor freely open, removes the coagula, and ligatures the artery on each side of the lesion, as was done in the following instance, during the late civil war:—

[1] Science and Art of Surgery, vol. i. p. 162.

A soldier, aged 23, was wounded in the right side of the neck, at Antietam, September 17, 1862, by a buckshot which hit the common carotid artery. A diffused traumatic aneurism ensued. On the 30th, the tumefaction, already enormous, was rapidly increasing; it crowded the trachea considerably to the left side. The covering of the aneurism was tense, and pulsation with a hard thrill was perceived on palpation. A plug of lint held firmly by clotted blood filled up the wound. Dr. R. F. Weir, U. S. Army, having carefully assigned their duties to his assistants, withdrew the plug, and quickly enlarged the wound with probe-pointed instruments, sufficiently to admit two of his fingers to the bottom of the cavity. He "was so fortunate as to reach and compress the opening in the artery with very little difficulty, and thus effectually control the hemorrhage. Throughout the whole of the operation it was noticed with what ease the bleeding from the artery was checked—so little pressure was required. The clots were turned out, and the incision prolonged downward to the clavicle, and upward about one inch—the length of the entire incision being three and one-fourth to four inches." Ligatures were passed around the artery with Mott's aneurism needle (Fig. 437), below and above the aperture, "which the end of the fore-finger neatly

Fig. 437.



Mott's aneurism needle.

closed." Less than eight ounces of blood were lost during the operation. Death, however, ensued, from a gunshot lesion of the spinal cord, and from cerebral softening. Nevertheless, the case very clearly shows the entire feasibility of this operation for diffused traumatic aneurisms at the root of the neck.[1]

The wound after the "old operation" for aneurism cannot be healed like an ordinary incised wound, but must be left to granulate; and great attention must be paid to the dressing. Having cut off the ends of the carbolized catgut ligatures close to the knots, and carefully washed out the cavity with a solution of potassium permanganate or of boracic acid, and afterward well sprayed it with carbolic acid, a drainage-tube should be introduced; and over all should be placed some carbolized lint or very soft oakum. As soon as suppuration begins, the wound must be dressed antiseptically every night and morning. The constitutional state of the patient must be provided for by administering nutrients, stimulants, and tonics.

II. Circumscribed Traumatic Aneurism.—This variety of aneurism does not, as a rule, present itself until some time after the injury that causes it occurs. In it, the blood that escapes from the canal of the injured artery is inclosed by a distinctly formed sac, which, in one large class of instances, consists of the external coat together with the sheath of the injured artery, and, in another large class, of laminæ of connective tissue condensed by the expansion-pressure, and by the products of inflammatory irritation.

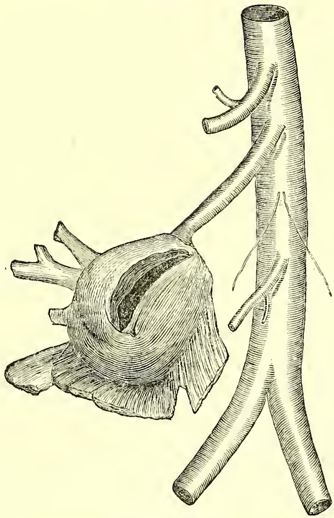
The accompanying wood-cut (Fig. 438) illustrates the first-mentioned class:—

It represents a preparation belonging to our Army Medical Museum,[2] of a circumscribed aneurism of the superior mesenteric artery, in which the sac consists of the outer tunic and the sheath. The inner and middle coats of the artery have burst; and,

[1] Med. and Surg. History, etc., First Surg. Vol., pp. 456, 457.
[2] Specimen 503, Sect. II.

inasmuch as no atheromatous change is discernible in them, and nothing appears to account for a spontaneous rupture, it is believed that they were lacerated by some traumatic cause. The tumor was recognized by its position and pulsation during the life of the patient, who died of another disease; but the antecedent history is, unfortunately, not recorded.[1] This sort of circumscribed traumatic aneurism is often produced by blows and strains; and I have presented a considerable number of examples of it in the foregoing pages. The inner and middle coats of the injured artery, on being torn through in this manner, gape open, and the pressure of the blood-stream expands the outer tunic and the sheath into an aneurismal tumor.

Fig. 438.

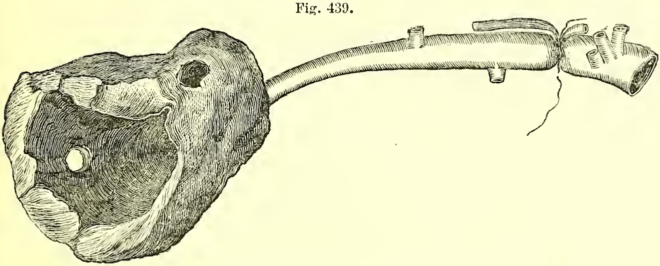


Circumscribed traumatic aneurism of the superior mesenteric artery.

The other frequent sort of circumscribed traumatic aneurism is illustrated by the following woodcut (Fig. 439):—

It also represents a preparation belonging to our Army Medical Museum,[2] which was obtained from the following case: A soldier, aged 28, received a shot-wound through the right shoulder and walls of the upper part of the thorax, implicating also the axillary artery,

Fig. 439.



Circumscribed traumatic aneurism of the right axillary artery; ligature of the subclavian performed too late.

on June 9, 1863. The external wound appears to have healed without any trouble. Internally, however, an aneurism was developed from the wounded axillary artery in the latter part of the following month (July). On the 28th of that month, "the true nature of the disease became manifest," on making a careful examination, "as the pulsation of the tumor—at that time about the size of a large horse-chestnut—was very apparent; and, upon auscultation, the aneurismal bruit could be distinctly heard. cor-

[1] Med. and Surg. Hist. of the War of the Rebellion, Second Surg. Vol., p. 25.
[2] Spec. 2609, Sect. I.

responding with the contractions of the left ventricle of the heart." The treatment by compression was tried in vain. By August 16, the tumor had become much larger, and now caused great pain. It was decided to ligature the subclavian artery; but, early the next morning the aneurism broke, and discharged from thirty to forty ounces of blood. The operation was performed, but death occurred six hours afterward, in consequence of the previous loss of blood.[1] In this case the external wound healed, but the injured tunics of the axillary artery, which doubtless were texturally disorganized by the graze or bruise caused by the impact of the missile, slowly gave way, and, as they yielded, the extravasation of blood was restrained by laminæ of connective tissue thickened by the products of inflammatory irritation, which ultimately formed the aneurismal sac.

Besides these, which are the common forms of circumscribed traumatic aneurism, two others are occasionally met with. One of them is *hernial* aneurism, an excellent example of which is reported in the *American Journal of the Medical Sciences.*[2]

In this case a small slice had been accidentally cut off from the sheath and outer tunic of the brachial artery, about two and one-half inches above the place of its division in an amputation of the arm. Secondary hemorrhage of an alarming character occurred from the stump, a consultation was held, aneurism of the brachial artery was diagnosed, and reamputation was recommended and performed. Examination of the reamputated portion showed a hernial aneurism of the brachial artery about two and a half inches above the ligature, where a small piece of the external coat had been shaved off by the amputating knife. Through this opening or ring, one-eighth of an inch in diameter, the inner and middle coats of the artery protruded, forming an aneurismal tumor, at least half an inch in diameter, and reminding one of the protrusion of a femoral hernia through its ring. The secondary bleeding had issued from a rent in the walls of this aneurism. Afterward the case did well.

In the second of these two rare forms of circumscribed traumatic aneurism, all the arterial tunics have been perforated, but the sac consists only of the external tunic and the sheath. It usually arises from a small puncture of a large artery, such as the axillary or the femoral. At first, the bleeding is profuse, but, being stopped by local compression, the external wound and the wound of the artery both heal up. Afterward the arterial cicatrix gradually yields, forming, at the end of weeks and months, a tumor which pulsates excentrically, with distinct bruit and thrill, and presents all the symptoms that characterize an aneurism from disease. The sac, too, is quite distinct, being formed by dilatation of the cicatrix in the sheath and external coat of the artery, without any blood being effused into the surrounding tissues. (Erichsen.)

*Symptoms.*—The circumscribed variety of traumatic aneurism is usually of less magnitude than the diffused, while it is much more tense and sharply defined. It pulsates excentrically, and exhibits the aneurismal bruit and thrill. It grows soft on compressing the parent trunk, and its pulsation, bruit, and thrill cease, to return again on discontinuing the pressure.

*Treatment.*—At first compression should always be tried, and, should it fail, ligation must be resorted to. In treating circumscribed aneurisms, traumatic as well as spontaneous, ligatures have been applied according to the plans of Anel, Hunter, and Brasdor, as well as according to the method of Antyllus, which is the "old operation."

On July 14, 1863, I ligatured the left subclavian artery, on Hunter's plan, for circumscribed traumatic aneurism, in a Confederate captain, aged 31, who, on June 21, had been shot through the left shoulder by a conoidal carbine-ball which severed the axillary artery. The bleeding ceased spontaneously, the wound healed kindly, and the

[1] Med. and Surg. History of the War of the Rebellion, First Surg. Vol., p. 545.
[2] No. for October, 1865, pp. 417, 418.

Fig. 440.

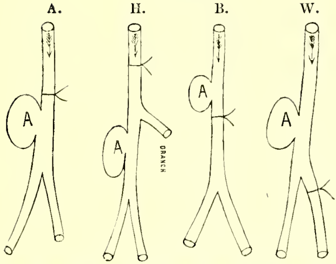
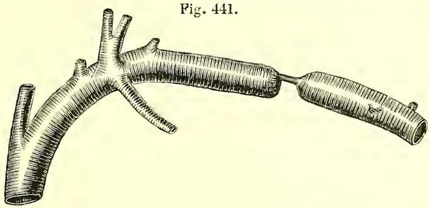



Diagram showing where the ligature is applied in Anel's, Hunter's, Brasdor's, and Wardrop's operations. (A.) In Anel's operation the ligature is applied to the artery on the cardiac side of the lesion, but between it and the first collateral branch. (H.) In Hunter's operation the ligature is applied to the main trunk on the cardiac side of the lesion, at a point much further from the lesion, and above the first collateral branch. (B.) In Brasdor's operation the ligature is applied to the main trunk on the distal side of the lesion. (W.) In Wardrop's modification of Brasdor's operation, the ligature is applied to a branch on the distal side of the lesion.

lesion of the artery gave no trouble until July 12, when a circumscribed traumatic aneurism as large as a pullet's egg was discovered. Between the 12th and 14th the tumor grew so rapidly that I feared to experiment with compression, lest meanwhile a rupture of the sac might ensue. It was so distinctly circumscribed, and resembled a spontaneous aneurism so closely in look and feel, that I thought Hunter's operation would almost certainly succeed, and accordingly I performed it. The wound made by the operation did well, and the ligature came away on the eighteenth day. Not so, however, with the aneurism; for on July 19 the sac suppurated, and discharged its contents through the anterior orifice made by the missile. The flow of purulent matter from the sac continued. On August 6, a violent secondary hemorrhage occurred, and several times recurred, until the patient died, on the 29th, worn out by the suppuration and the loss of blood. *Autopsy*—The distal end of the artery was found closed. The proximal end was found open, and from it the secondary hemorrhage had issued, the blood being derived from a reflux through the axillary branches into the axillary

Fig. 441.



Ligation of the left subclavian artery for circumscribed traumatic aneurism of the axillary: failure from secondary hemorrhage occurring in the wound.

trunk, and so through its open mouth, on the establishment of a collateral circulation. The only operation which could have prevented this mishap was the old one. The artery is preserved as a preparation in our Army Medical Museum.[1] It is also represented in the accompanying wood-cut (Fig. 441). In all cases like this, the "old operation" will afford a much better chance of saving the patient than the operation of Hunter or of Anel. The best method of performing the "old operation" in the arm-

[1] Spec. 1684, Sect. I.

pit I have already described with minuteness, while describing the lacerated wounds and ruptures of the axillary artery (p. 160). It is unnecessary to repeat it here.

On July 16, 1863, I was brought as consultant to the Post Hospital at Camp Barry, to see an immense pouch-shaped, though circumscribed, traumatic aneurism of the left femoral artery, in a soldier, aged 26, who had been wounded in the left thigh on May 26, by a pistol-ball, which grazed the femoral artery. The aneurism had already been treated by compression without benefit. So illy satisfied was I with the operation of Hunter in the case just related, that I imperatively insisted on the performance of the "old operation" in this case, and I also aided in its execution. The extent of the aneurismal tumor and the method of performing the operation are well shown by the accompanying diagram (Fig. 442). The aneurism extended from about two inches below

Fig. 442.

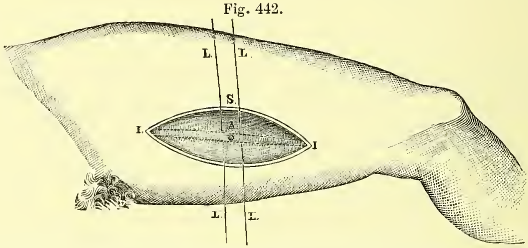



Diagram illustrating the length and course of the incision, the aperture in the artery, and the site of the ligatures, in a case of immense pouch-shaped circumscribed traumatic aneurism, which was treated successfully by the "old operation."

A, The aperture in the artery. II, The incision. LL, LL, Ligatures placed above and below the aperture.

Poupart's ligament down to within four inches of the knee-joint. The femoral artery was compressed digitally on the os pubis during the operation. The tumor was opened by an incision about eight inches in length. The sac was quite smooth internally, and contained but little coagulum. The aperture in the artery was small and oval-shaped. The blood that flowed from the distal part of the artery was venous-hued and without jets. No unpleasant symptoms whatever followed. The patient began light duty seven weeks after the operation, and soon was as well as ever. The scar of the wound of operation measured six and one-half inches in length.[1]

When secondary hemorrhage occurs after the "old operation" for aneurism, the blood usually issues from the distal orifice because it has been insecurely tied. In such a case the wound should be reopened, and the ligature should be reapplied without delay. Thus Mr. Joseph Bell, in a case where he had performed the "old operation" for traumatic axillary aneurism, on the occurrence of secondary hemorrhage from the distal end of the artery, laid the wound open and tied the end again. The patient recovered.[2]

Many instances are related in the surgical history of the late civil war, in which the "old operation" for traumatic aneurism proved successful; and many instances, also, in which there was failure because other plans of operating were employed.

Esmarch's elastic ligature and elastic bandage are capable of affording great assistance in performing the "old operation" for traumatic aneurism in the extremities, both upper and lower. By a judicious application of these devices, this procedure can generally be executed with but little or no loss of blood.

[1] The histories of this and of the preceding case are reported at length by the author in the U. S. Sanitary Commission Surgical Memoirs, vol. i. pp. 101–120. New York, 1870.

[2] British Medical Journal, Feb. 22, 1879, p. 289.

*Palmar aneurisms* are best treated by applying Esmarch's apparatus, laying the tumor freely open under ether, turning out the clots, bringing into view the ends of the wounded artery, and tying them with carbolized catgut, without any loss of blood.

*Traumatic aneurisms* of the *vertebral artery* are not very uncommon. Kocher has collected twenty-one cases. No instance of spontaneous aneurism of this artery is on record. For vertebral aneurisms the treatment by compression must be tried. Should the tumor burst, or appear likely to burst, it should be freely opened with suitable precautions, and an effort should be made to tie the artery above and below; or, that failing, the artery must be cautiously plugged above and below with prepared agaric or some similar substance.

In examining traumatic aneurisms of the pelvis for therapeutic, as well as for diagnostic purposes, important information may sometimes be obtained by exploring the pelvic cavity with a hand introduced within the rectum, as I have already pointed out in the section on Wounds of the Pelvic Bloodvessels.

## Arterio-Venous Wounds; Aneurismal Varix and Varicose Aneurism.

Several examples have already been presented, in which the vulnerating body simultaneously opened a large artery and its accompanying vein, thus producing an arterio-venous wound. The following abstract, with the accompanying diagram, represents another case, which was reported by Dr. David Prince:—

A soldier, aged about 20, accidentally shot himself with a small pistol, October 21, 1864. The missile entered the left side of his neck, an inch from the median line, and on a level with the pomum Adami; it passed almost through, and lodged under the integuments just below the left occiput. The bleeding ceased spontaneously, and a considerable swelling formed. Oct. 28, a very distinct thrill was felt, and a loud whizzing murmur was heard in the tumor. Oct. 29, the wound having bled slightly in the night, the common carotid was ligatured below the omo-hyoid. Nov. 3, at 3 A. M., the patient died of cerebral softening or anæmic gangrene of the brain. *Autopsy*—The common carotid artery was found notched, and the internal jugular vein perforated, as shown in the accompanying wood-cut (Fig. 443). No distinct aneurismal sac had formed, and no embolism of the cerebral arteries had occurred.[1]

Fig. 443.

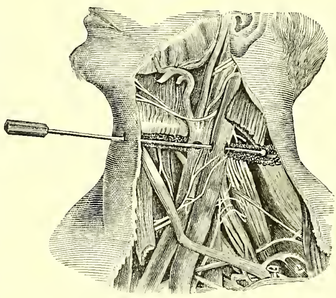


Diagram to illustrate an arterio-venous wound of the neck.

But wounds which simultaneously open the carotid artery and internal jugular vein, as well as wounds which open other large arteries and their attendant veins, do not always prove fatal; for, if their extent be small, and the circumstances otherwise favorable, they may result in forming aneurismal

[1] U. S. Sanitary Commission Surgical Memoirs, vol. i. pp. 146–148. New York, 1870.

varices or varicose aneurisms. When the lips of the wound in the artery adhere closely to the lips of the wound in the vein, and the blood flows from the artery directly into the vein, *aneurismal varix* results; but when the lips of the wound in the artery adhere less closely to the lips of the wound in the vein, and the pressure of the arterial current separates the wall of the artery from the wall of the vein, and the blood, by condensing before it the lamina of fascia and connective tissue at the wound, forms a pouch or sac lying between the two vessels, *varicose aneurism* results. The prognosis in a case of aneurismal varix or varicose aneurism is much less serious than it is when the artery alone has been opened; for a portion of the arterial blood is projected into the vein at each pulsation, and thus the pressure or strain upon the injured parts is considerably lessened. Thus, too, the occurrence of great swelling and of rupture is usually avoided.

Aneurismal Varix.—By this term is meant an enlarged and tortuous, or varicose, condition of a vein, resulting from a simultaneous wounding of the vein and its contiguous artery, whereby a communication between the two vessels is established. The arterial blood which is projected into the vein at each pulse-beat, dilates it more or less extensively, and causes its wall to thicken.

Dr. William Hunter first described this lesion.[1] Scarpa, however, claims that Guattani should equally share the merit of the discovery, because he

Fig. 444.

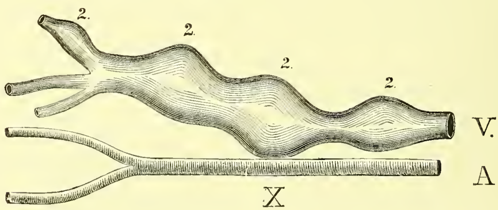



Diagram illustrating aneurismal varix. A, The artery. V, The vein. X, Site of the aperture of communication between the artery and vein. 2, 2, 2, 2, Varicose enlargements of the vein, with thickening of its walls.

published two undoubted cases of aneurismal varix.[2] But, Dr. Hunter's observations on this disorder were published in the years 1757 and 1764; while Guattani did not see his first patient until the year 1769, and his book was not published until the year 1772. An instance of this disorder had previously been mentioned by Sennertus.

*Symptoms.*—With the history of a previous wound, aneurismal varix is characterized by a circumscribed tumefaction, usually small and bluish in color, formed by a dilated vein, possessing a peculiar tremulous motion, and attended with a peculiar thrilling, hissing, or buzzing noise which arises from the passage of blood through a small aperture in the artery into the dilated vein. This peculiar sound is sometimes said to be like that made by a fly on a pane of glass, or in a paper bag. The tumor is generally accompanied by a varicose state of the neighboring veins. It is soft, and disappears entirely under direct pressure. It subsides when the limb is elevated so as

[1] Medical Observations and Inquiries, vol. i. p. 340; and vol. ii. p. 390.
[2] Treatise on Aneurism, Wishart's translation, p. 190.

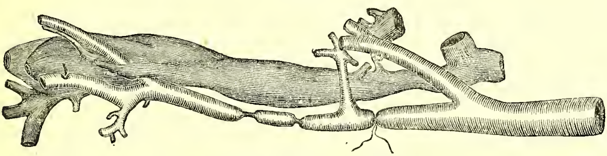
to favor the return of venous blood toward the heart, and, in the same way, its pulsation is lessened. But, when the limb hangs down, or pressure is applied to the vein on the cardiac side of the tumor, it enlarges or forms a more considerable swelling. Compressing the vein on the distal side of the tumor does not lessen either its size or its pulsation. When, however, the artery is compressed on the cardiac side of the tumor, the pulsation immediately ceases, and it instantly returns on raising the compression. The trunk of the artery, after a time, becomes considerably enlarged; and it pulsates more strongly than the corresponding vessel in the other limb. But, on the distal side of the tumor, the arteries get smaller and pulsate less strongly than they do in the corresponding part of the other limb. The sounds can often be heard in the veins at a considerable distance.

Aneurismal varix usually progresses but very slowly. There are cases on record in which no increase was observed for 18, 20, and even 35 years. When, however, the varicosities do enlarge, much evil may ensue from the pressure exerted by them. The obstruction to the venous circulation will cause œdema and cyanosis of the affected limb, and a lowered temperature, with ulceration or sloughing of the varicosities themselves, followed by hemorrhage, and sometimes by gangrene.

The following example was reported during the late civil war; it will serve to illustrate the symptoms and progress of this lesion:—

The patient was a soldier, aged 24. When a youth of 16, he was accidentally wounded with a pocket-knife, at the inner part of the left thigh, about two inches below Poupart's ligament, the blade puncturing the femoral artery and vein near the origin of the profunda. Profuse hemorrhage ensued, but it was arrested by compression; the wound healed, and in a week the patient went to work again as a farmer. Afterward he had no trouble, except sometimes a slight pain in the track of the wound after unusual exertion, until August, 1863, eight years after the accident, when, being now in the army, his limb suddenly swelled, in consequence of hardship and a long, fatiguing march, so as to measure thirty-two inches in circumference. On

Fig. 445.



Aneurismal varix of left thigh. Terminal portion of aorta and both iliac arteries also shown, with a ligature in position on the left one. (Spec. 3597, A. M. M.)

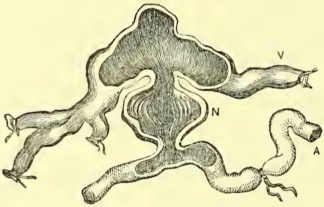
November 12, he entered the military hospital at Newark, N. J. The left thigh was much swollen, with œdema and varicosities, and presented a cyanosed appearance; an aneurismal thrill and bruit were also observed. On February 6, 1864, the external iliac artery was ligatured, but without benefit. In the following summer, the thigh became enormously distended, and a number of openings which had formed in it put on a gangrenous appearance. At the end of August the thigh measured thirty-seven inches in circumference, and its veins appeared more distended than before the operation. On September 17 the common iliac artery was ligatured, and on the fifth day afterward the patient died of peritonitis. A preparation was made of the vessels involved, which is preserved in our Army Medical Museum.[1] It is represented in the wood-cut above (Fig. 445). The ligature on the common iliac is shown

[1] Spec. 3597.

*in situ.* A constriction shows where the external iliac had been tied. The femoral artery appears constricted from imperfect injection. The much expanded and varicose condition of the femoral vein is well exhibited.[1] The œdematous and cyanotic tumefaction, with gangrenous ulcerations, which the aneurismal varicosities produced in this case, was well marked. The failure of the operations of Anel and Hunter to afford relief was also quite conspicuous.

Varicose Aneurism.—By this term is meant a circumscribed traumatic aneurism which communicates on one of its sides with the artery from which it springs, and, on the opposite side, with an aneurismal varix. This lesion is well illustrated by the accompanying wood-cut (Fig. 446).

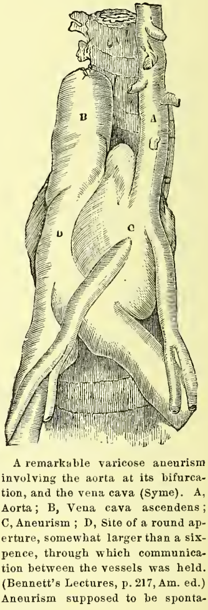
Fig. 446.




A varicose aneurism; the sac lies between the brachial artery and the median basilic vein, and communicates with both. (After Sir C. Bell.)

A, the *brachial artery;* V, the *median basilic vein* with an *aneurismal varicosity;* N, the *aneurismal tumor*, which is connected with the artery beneath it by a minute aperture, and with the aneurismal varicosity above it by another small opening.

Fig. 447.




A remarkable varicose aneurism involving the aorta at its bifurcation, and the vena cava (Syme). A, Aorta; B, Vena cava ascendens; C, Aneurism; D, Site of a round aperture, somewhat larger than a sixpence, through which communication between the vessels was held. (Bennett's Lectures, p. 217, Am. ed.) Aneurism supposed to be spontaneous.

The *symptoms* of varicose aneurism are those of aneurismal varix, just presented above, together with the symptoms of circumscribed traumatic aneurism. On expelling the blood from the varicosity by applying direct pressure, the aneurismal tumor still remains. In some very rare instances varicose aneurism has had a spontaneous origin. (See Fig. 447.)

Localities of Arterio-venous Aneurism.—Arterio-venous aneurisms have most frequently been met with at the bend of the elbow, where they have arisen from punctures during venesection. M. Goupil states that in thirty-one out of fifty-seven cases the lesion was caused in this way. Dr. S. W. Gross has collected ten examples in which arterio-venous aneurisms occurred in the neck; in eight there was aneurismal varix, and in two, varicose aneurism. In all of them the internal jugular vein was involved, together with the primitive carotid artery in six instances, and the internal carotid in the remaining four. In none did the lesion appear to shorten life or cause much inconvenience. The lesion was caused by incised or punctured wounds in seven, and by gunshot wounds in three instances. In several of them the aperture in the integuments was so made that it did not gape when the

[1] Medical and Surgical History, etc., Second Surg. Vol., p. 336.

weapon was withdrawn.[1] Baron Larrey recorded three cases in which aneurismal varix of the axilla occurred in consequence of incised wounds involving the axillary artery and vein. M. Bérard reports a case observed by Dupuytren, in which it was caused by a gunshot wound of the axilla. Dr. J. C. Nott, in 1841, reported a case of successful ligation of the subclavian artery for arterio-venous aneurism. Dr. J. P. C. Wederstrandt also reports an aneurismal varix following a gunshot lesion of the subclavian vein and artery, which the patient survived seven years, finally dying of another disease. M. Legouest, too, relates a case that resulted from a musket-ball wound of the left axilla, at Balaclava.[2] Above I have presented an example of aneurismal varix of the left thigh, which was caused by an incised wound of the femoral vein and artery. Hennen records a case in which aneurismal varix of the right thigh was caused by a musket-ball wound of the same vessels.[3] Many examples of arterio-venous aneurism of the thigh have been reported. Furthermore, Dorsey has detailed a case in which aneurismal varix of the leg resulted from a gunshot wound.[4]

Treatment of Arterio-Venous Aneurisms.—Arterio-venous aneurism in the neck, as far as the published cases enable us to judge, does not often prove fatal, if it be let alone. This lesion should not be interfered with, unless, from its growth, inconvenience arises or danger is threatened. In some comparatively rare instances this will happen. Then the treatment by compression should first of all be tried. Medini reports a very unpromising case of arterio-venous aneurism of the neck, which was completely cured by steady, long-continued pressure applied with Signorini's tourniquet.[5] Should compression fail, ligation must be resorted to. On theoretical grounds, Anel's and Hunter's plans of ligation have often been employed, but, on the whole, with very disastrous results. I have already presented such an example of disastrous failure. Follin has collected ten instances of arterio-venous aneurism occurring in the lower extremity, of which five were treated by placing a ligature on the cardiac side of the lesion, as in Anel's or Hunter's operation, all of these ending fatally. He also has collected nine examples of arterio-venous aneurism occurring in the upper extremity that were treated in the same way; three terminated fatally; in five cases there were relapses; in one a cure was reported. The most frequent cause of death was gangrene.[6] The late Prof. Spence published an example of arterio-venous aneurism of the thigh, which was successfully treated by ligaturing the femoral artery above and below the lesion.[7] There are on record a considerable number of cases that were successfully treated on this plan.

When it becomes imperative to operate, the proceeding which promises the best result is to carefully dissect the skin from the tumor, having previously applied Esmarch's apparatus for the bloodless operation, and, on exposing the injured artery, to ligate it above and below the lesion with carbolized catgut. When feasible, a third ligature should be passed around the channel of communication between the vein and the artery, in order to avoid any possible failure arising from that source. The difficulties attending this operation must not be underestimated; and the surgeon, when about to under-

[1] American Journal of the Medical Sciences, 1867, January, pp. 44–46; April, pp. 339–340.

[2] Med. and Surg. History of the War of the Rebellion, First Surg. Vol., p. 612.

[3] Military Surgery, pp. 158, 159.

[4] Nouveau Dictionnaire de Méd. et de Chirurg. pratiques, t. xix. p. 586. Paris, 1874.

[5] Bulletino delle Scienze Mediche, Jan. 1880; London Medical Record, April 15, 1880; Med. News and Abstract, June, 1880, pp. 363, 364.

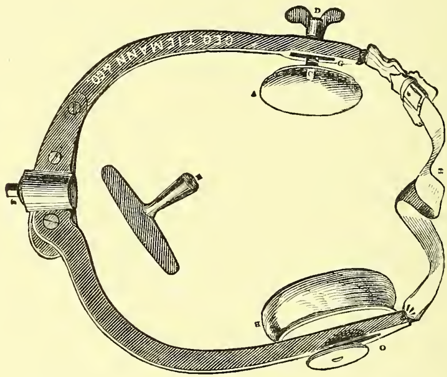
[6] Med. and Surg. History, etc., Second Surg. Vol., p. 337. Foot-note 3.

[7] Edinburgh Medical Journal, July, 1869; American Journal of the Medical Sciences, October, 1869, p. 562.

take its performance, should call to mind the regional anatomy of the part, and the structural changes which may possibly have taken place. The wound of operation must be treated antiseptically.

The accompanying wood-cuts illustrate two ingenious forms of instrument well suited for the compression treatment of any form of aneurism:—

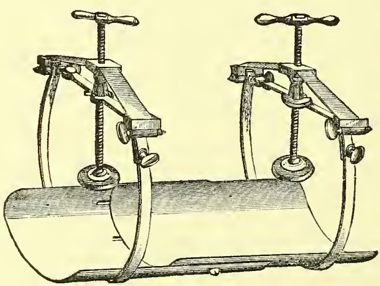
Fig. 448.



May's tourniquet for the treatment of aneurism. A. Pad of pressure. B. Pad of counter-pressure. C. Ball and socket-joint in the pad of pressure, which is governed by the screw and nut D. E. Key by which, when applied on F, the pads can be approximated or separated. G. Fenestræ, by which the pads can be adjusted. H. Strap and buckle.

The action of Briddon's instrument (Fig. 449), is made *elastic* by running the screws through tense India-rubber bands; it can be tolerated for a long time without producing any annoying complication.

Fig. 449.



Briddon's artery-compressor for the treatment of aneurism.

Pressure can be made at *two* points, the distance between which may be varied according to circumstances, or the instrument may be taken apart, and then a single

compressor may be used as a tourniquet. A smaller instrument can be made for the upper extremity; also a larger one for compressing the abdominal aorta.

The hard rubber compressors are attached to the screws by ball and socket-joints, and they are fitted into concavo-convex caps of wood, protected by several layers of buckskin, which are put on just before screwing down, and should be well powdered each time that they are applied.

## Gangrene from Arterial and Venous Occlusion.

When, from the injuries of bloodvessels, mortification ensues, it is because the supply of normal blood, that is, of blood which is fit to sustain calorification and the normal processes of cellular and molecular nutrition, is so much impaired by the injuries themselves, that molecular as well as cellular life is extinguished, and putrefaction inaugurated, throughout the affected area. Gangrene from this cause is frequently met with, and very often proves fatal. Many instances have been mentioned in the foregoing pages, and in nearly all of them death occurred. The subject is therefore very interesting and important to the surgeon.

Symptoms.—Calorification being suspended, the temperature of the affected part sinks to that of the surrounding atmosphere, unless it is kept up by artificial heat. The nervous sensibility, muscular contractility, and muscular elasticity are likewise abolished; and a great weight, with, sometimes, great pain also, is felt in the affected limb or area; the beating of the arteries, too, is no longer perceived in the affected region, but still the part is not yet wholly dead. The natural heat, sensibility, motility, and arterial pulsations, have been known to return eight days after these and other signs of gangrene had been observed and accepted. Changes in color also take place. The integuments assume a tallowy-white, dirty-yellowish, marbleized, or brownish appearance. Dark-red streaks may form over the course of the superficial bloodvessels. Large vesicles or blebs, filled with a pale or a dark serum, not unfrequently appear. The epidermis becomes detached; the color blue-black, then greenish; putrefaction ensues; emphysema from decomposition may distend the subcutaneous connective tissue and crackle under the fingers when pressed on; and the peculiarly fetid odors which characterize mortification are sent forth to taint the air, oftentimes in spite of the liberal use of deodorizers and disinfectants. Occasionally, the sphacelus does not extend above the middle of the limb, as has been observed after the operation for popliteal aneurism; more frequently it extends up to the ligature or the wound which produces the vascular occlusion; but very rarely to a higher point.

Causes.—The *proximate* cause of anæmic gangrene is insufficiency in the supply of nutrient blood. The *efficient* causes are the vascular lesions which produce this insufficiency.

The traumatic lesions of bloodvessels which eventuate in mortification affect, (1) the *main arteries;* (2) the *main veins;* and, (3) the *collateral channels.*

The office of the collateral channels is vicarious as well as supplemental to that of the main channels, and is of such extreme importance in the animal economy that, when their constitution is normal and their operation wholly unembarrassed, it is almost impossible for anæmic gangrene to result from traumatic causes. The injuries of the arterial and venous trunks which induce mortification are always complicated with traumatic lesions, or impaired action, or imperfect development of the collateral branches. This

point is mentioned, *in limine*, because of its great practical importance. When the great vessels of the extremities are occluded in accidents or in surgical operations, our sole hope of maintaining the vitality of the member often rests upon protecting the collateral branches from pressure and from obstruction in every form.

I. Gangrene from Arterial Occlusion.—The lesions of the main arteries which cause anæmic gangrene are (1) *complete division*, of which a considerable number of instances have been mentioned in this article; (2) *occlusion from the division and recurvation of their inner and middle coats*, of which a considerable number of cases were mentioned in the section on lacerated wounds and ruptures of arteries; (3) *occlusion by compression from blood extravasated* within the arterial sheath in consequence of contusion; (4) *occlusion from traumatic thrombosis*, the result of arterial contusion and inflammation; (5) *occlusion from traumatic embolism*, the migratory plugs consisting of blood-clots formed or detached in consequence of injuries; and (6) *occlusion from ligation*, or the application of ligatures. Several examples illustrating the last three forms of arterial lesion, in which gangrene ensued, have also been mentioned in the foregoing pages. When anæmic gangrene results exclusively from arterial obstruction, and no impediment whatever exists to the flow of venous blood, it is always a *dry gangrene*.

II. Gangrene from Venous Obstruction.—If we apply to a limb circular compression sufficient to intercept the course of the venous blood, as sometimes has been done by bandaging fractured limbs too tightly, the limb swells, turns livid, and mortifies. The tissues perish because the effete or venous blood cannot pass out so as to give room for the fresh arterial blood to enter and nourish them. Thus, venous obstruction, in rare instances, causes mortification, by leaving no way of escape for the blood which has been carried into a limb by the arteries, and has there become exhausted of its nutrient properties, or effete. This, however, cannot well happen unless the compression be circular. The venous canals are, as a rule, more numerous, as well as more capacious, than the arteries, so that when one trunk happens to be obstructed, the others are usually found ready to perform its office. Not so, however, when several contiguous trunk-veins are occluded; or in cases, where all the vessels of a limb are strongly compressed by a profuse infiltration of serum, or by a copious extravasation of blood, or by a wide-spread effusion of the products of inflammation into the connective tissue of a limb, where the fasciæ or aponeuroses, both superficial and deep, being strong and unyielding, act like circular bands to strangulate the parts. Gangrene from venous obstruction is always *humid*.

The injuries which obliterate the venous canals are *severance*, *traumatic thrombosis*, *deligation*, and *compression*. Many examples of these have been presented in the foregoing pages. The occurrence of venous obstruction is denoted by the development of a cyanotic tumefaction of the limb, wherein the swollen subcutaneous veins can usually be discerned beneath the purple or venous-hued skin; also, by the development of a wide-spread œdematous infiltration, by which the affected limb sometimes becomes enormously distended, presenting the features characteristic of *phlegmasia alba dolens*.

III. Gangrene from Obstruction of the Collateral Circulation.—Do the anastomosing branches of arteries (that is, their collateral channels) really perform the important part which I have claimed for them in the causation of anæmic gangrene? Here, as everywhere else in the domain of practical surgery, the lessons derived from clinical observation are all-important; and

the two annexed examples will serve to answer this question, and to illustrate the subject in a useful manner:—

A man was wounded in the axilla by a sword, and much blood was instantly lost; a large tumor rapidly filled the axilla, and the man fainted. On the fourth day, the forearm was cold, and the skin on it of a yellowish tint; hemorrhage recurred. The tumor increased, and was attended with obscure pulsation; the skin covering it was red and tense. In this state, on the seventh day, the man entered the Hôtel-Dieu. Desault laid the swelling open by an incision six inches long, commencing underneath the acromial third of the clavicle, and extending downward and outward. A great quantity of coagulum, followed by a stream of fresh blood, rushed forth, in spite of the compression which was applied to the subclavian artery above the clavicle. Desault seized the mouth of the artery (it was divided above the origin of the subscapularis) with his finger and thumb, and thus commanded the hemorrhage. The lower as well as the upper end was then ligatured. In the evening, after the operation, obscure pulsation was observed at the wrist, and the limb had in some degree regained its natural heat. The veins on the back of the hand and arm were filled with blood. No doubt existed that the circulation was re-established. On the third day after the operation, suppuration had commenced, and sloughs were observed in the wound. On the fourth evening an erysipelatous redness was noted on the forearm. On the next day the temperature of the limb fell, the nails became dark-colored, and purple spots appeared on the arm. On the sixth day after the operation the limb was vesicated and gangrenous, and the patient died.[1]

In this case, mortification had occurred after the circulation had been re-established through the collateral channels; and must, therefore, have been due to obstruction of those channels, which might readily have resulted from compression caused by infiltration of the connective tissue surrounding them with inflammatory products, that is, from compression caused by inflammatory swelling, the inflammatory process having spread from the suppurating and sloughing armpit to the shoulder.

Hodgson mentions another example of the same sort:—

An officer received a stab-wound of the axillary artery by a sword. He soon fainted, and the hemorrhage ceased. The vessel was ligatured a short distance above the wound. The arm was then cold, and no pulsation could be felt in its arteries. On the third day, however, the arm was perfectly warm, and its veins were turgid with blood; but on the fourth day gangrene attacked the shoulder, and the patient died in the evening. *Autopsy*—The axillary artery was found completely divided below the origin of the circumflex. The ligature included also three of the brachial nerves. The axillary vein was wounded, but not included in the ligature.[2]

In this case, also, mortification occurred after the circulation had been perfectly re-established by means of the anastomosing branches or collateral channels at the shoulder. Inasmuch as the appearance of gangrene cannot be accounted for by the lesion of the brachial nerves, it must be ascribed to obstruction of the collateral circulation, which was probably caused by the extension of inflammatory swelling from the wounded armpit to the shoulder.

The collateral channels may be dangerously obstructed by pressure exerted upon them from careless bandaging, or by the position in which a limb may be placed, as well as by the compression which arises from œdematous, inflammatory, and hemorrhagic swelling. The aponeuroses or fasciæ cause strangulation only by acting as unyielding bands.

The simultaneous occlusion of the main artery and vein of a limb does not cause mortification, unless the collateral channels are also obstructed. In

[1] Œuvres Chirurgicales de Desault, par Bichat, t. ii. p. 553.
[2] Op. cit., pp. 355, 356.

some examples of this sort, wherein gangrene occurred, that have been related above, the collateral channels, both arterial and venous, were obstructed by pressure from œdematous and inflammatory swelling.

The cerebral softening which sometimes follows deligation of the common carotid artery is usually anæmic gangrene of the brain.

Treatment of Gangrene from Vascular Obstruction.—When wounds have been received, or when surgical operations have been performed, which are liable to cause anæmic gangrene, the treatment should be so conducted as to keep the collateral channels free from obstruction. When from any cause we ligature the principal vein as well as the principal artery of a limb, special care should be taken to cherish the collateral circulation, both at the time of and subsequent to the operation. The causal indications must always be met, as far as possible, by abating inflammatory and other swellings. Strangulating aponeuroses or fasciæ should be divided by appropriate incisions. The old plan of treating gunshot wounds by dilating them with the knife, lessened the liability to mortification.

In some situations, as, for instance, at the bend of the knee, obliteration of the main artery, when it is attended with much injury of the surrounding parts, is so sure to be followed by gangrene as to make primary amputation advisable.

In gangrene from the occlusion of bloodvessels, no line of separation, as a rule, is formed. There is, therefore, nothing to prevent the flow of putrid blood and other products of decomposition from the mortified part into the rest of the organism. Hence arise the great risk of septicæmia and the great fatality in these cases. Hence, too, amputation should be performed not very far below the site of the vascular lesion, as soon as gangrene appears.

Early amputation, likewise, affords the only means of preventing the gases which result from decomposition in the gangrenous part, from entering the veins and passing on to the right side of the heart, thus causing sudden death, as happened in several cases reported by M. Parise,[1] which I have already mentioned in speaking of air in veins.

Antiseptic precautions during, and antiseptic treatment after, the operation are of great importance.

## Hæmophilia, or the Hemorrhagic Diathesis.

This disease is attended with a remarkable propensity to bleed, on very slight or even without any apparent provocation. Hence those subject to it have been familiarly called *bleeders.*

Definition.—Hæmophilia may be defined as a *congenital* and *habitual* disposition to the occurrence of hemorrhage. The extremely obstinate and dangerous hemorrhages for which bleeders are noted, usually begin in the very *earliest* years of life, and *habitually* recur. It is very uncommon for this peculiar hemorrhagic habit to originate in middle life so as to warrant us in regarding the disposition as acquired. It is equally uncommon for one who was a marked bleeder in infancy, and in whom the disposition was congenital, to completely lose the idiosyncrasy in early youth, and remain thereafter free from hemorrhagic attacks. In fact, the *congenital* origin and *habitual* nature of the disposition are so constantly observed together in the so-called bleeders, that although each of these attributes is doubtless important by itself, it is

[1] Archives Gén. de Méd., Novembre, 1880.

unquestionably their combination that constitutes the chief characteristic of hæmophilia. (Immermann.) It is just these two attributes which chiefly distinguish hæmophilia from other hemorrhagic affections, particularly scurvy and purpura hæmorrhagica. All of the other forms of hemorrhagic diathesis, especially the two just mentioned, present neither of these attributes, but are essentially acquired and transitory processes. Hæmophilia, on the contrary—at least as far as we can judge from the clinical phenomena—does not appear in any true sense a pathological process or morbid "accident," but rather an abnormal "condition" of the living organism, and probably depends for its material substratum not upon any tissue-change which runs a definite course, but rather upon an original vice of structure.

History and Geographical Distribution.—Our knowledge of hæmophilia as a specific disorder is, excepting the reports of a few ancient cases, entirely a modern acquisition. Toward the close of the last century, reports of families whose members were peculiarly subject to it began to be published in England (1784), in Germany (1793), and in America (New York, 1794). The word "bleeder" appears to have been first used in America. Nevertheless, it is to German writers that we are principally indebted for our knowledge of the subject.

This disorder, geographically, is not uniformly distributed, but is much more prevalent in some countries than in others. For, of 219 families, in which occurred 650 authentic cases, 94 lived in Germany, 52 in Great Britain, 23 in North America, 22 in France, 10 in Russia and Poland, 9 in Switzerland, 6 in Sweden, Norway, and Denmark, 2 in Holland and Belgium, and 1 in the island of Java; total, 219. (Immermann.) Thus, it appears that the Anglo-Germanic race is peculiarly susceptible to this disease. The Latin races, however, are not entirely exempt, for France is credited above with 22 bleeder families.

Etiology.—Family transmission is unquestionably the most striking and important of all the known causes of hæmophilia. Grandidier speaks of it as "the most hereditary of all hereditary diseases." Immermann finds that the 650 authentic cases of bleeders have been distributed among 219 families, or very nearly three bleeders to a family. In fact, when one case occurs in a group of blood-relations, other members, sooner or later, are almost always affected. The disease, when having its starting-point in a single individual, or in several members of a family whose parents and ancestors were entirely free from it, is capable of *direct transmission* from one generation to another. For instance, the disease could be directly traced in two of the American bleeder families through the entire interval from 1720 to 1806; and of two unrelated bleeder families at Tenna, in Granbünden, one at least has been affected since 1770, and in the two families together the affection had gained such headway by the year 1854, that, at Tenna alone, out of a total population of 165, there were at that date no less than 15 bleeders. But the most important mode of propagation is by means of what may be called *indirect transmission*. Thus, after one or more cases have appeared among the children of healthy parents, the disorder is usually handed down, not as much by the bleeders themselves as by their non-bleeder brothers and sisters, and this singular mode of transmission of the outward manifestations of the disease may be repeated for several generations. A very large number of actual bleeders die from the disease so early in life as to be unable to take any share in the propagation of the anomaly. But the bleeder families present another remarkable peculiarity, to which attention was first called by Wachsmuth, namely, the *extraordinary fruitfulness* of the non-bleeder bro-

thers and sisters; for direct investigation has shown that the average number of legitimate births in bleeder circles is nearly twice the general average. (Immermann.) Hence, hæmophilia is a disorder of terrible importance to the welfare of the families concerned.

Hæmophilia, fully developed, occurs in *males* much more frequently than in females. Of 650 authentic cases, there were 602 in males and only 48 in females. In hardly any other disorder is the predisposing influence of sex so strikingly apparent. So, too, in bleeder families, it is much more common for the sons alone to be affected than for the sons and daughters, or the daughters alone. When the disease appears in both sexes in such families, the number of male bleeders usually exceeds that of the female bleeders; and, finally, the instances are much more numerous where all the sons without exception are bleeders, than where the disease attacks all the children, daughters as well as sons, or all the daughters alone. Such facts clearly show that the predisposing influence of sex, in this regard, is not merely a general law governing the gross statistics, but is likewise a radical differential principle, the operations of which are special in character, and discernible even in the smaller groups that are represented by the children of single families.

But, while females are far less subject to fully developed hæmophilia than males, the actual share of the female sex in cases which, although not fully developed, really belong to the pathological domain of hæmophilia, is in all probability much larger than appears from the statistics just given, or perhaps than can possibly be shown by any statistics. It is not unlikely, as Grandidier has pointed out, that imperfectly developed and anomalous outbreaks of the bleeder disposition, which are manifested only transitorily and at certain times, *e. g.*, at the first appearance of the menses, and in childbirth, etc., are really more frequent in females than is commonly supposed, the true relation of these attacks to hæmophilia being overlooked. In girls, the diathesis often remains latent to a certain extent, and frequently is first brought into activity by fixed causes apparently connected with the period of reproductive activity. How often may not, indeed, hemorrhage in a hæmophilic puerperal woman have been quoted as the result of defective involution of the uterus, or fatal flooding as the result of atony of the womb? Moreover, the female sex is in reality to be regarded as the more intensely affected, because it possesses in a far higher degree than the male the capacity for transmitting the disease by inheritance to its offspring. For, as Grandidier also has pointed out, the males in bleeder families who themselves are bleeders, do not, as a rule, beget bleeder children by women who belong to non-bleeder families; in fact, the children in such cases are usually healthy and non-bleeders; but the children of women who themselves are bleeders are quite uniformly affected with hæmophilia. Again, the males in bleeder families who themselves are not bleeders, almost never beget bleeder children by women from other families; but among the children of women who belong to bleeder families, and are not themselves bleeders, some are almost always found who suffer from pronounced hæmophilia. In the transmission of this disorder, therefore, the maternal influence is far more important than the paternal; and, since the females are but rarely fully developed bleeders, while the male bleeders either die prematurely, or, as a rule, fail to reproduce the disease in their children, it follows that the non-bleeder women in bleeder families are, in fact, the most frequent and most efficient "conductors" of hæmophilia, and to them the hitherto constantly increasing spread of this affection is mainly due.

The first bleedings of hæmophilia take place in *very early childhood*, in a very large majority of instances. A considerable number of deaths have been reported in Jewish families from the rite of circumcision on the eighth day, as well as similar results in other families from cutting the frænum lin-

guæ soon after birth, or from accidental wounds. But the most common time for the full outbreak of the disease is at the end of the nursing period, or at the beginning of the first dentition, not only because the traumatic bleedings now become more frequent in consequence of slight contusions, excoriations, etc., but especially because the apparently spontaneous hemorrhages begin to appear about this time. There are also certain ages when the disposition to bleedings is particularly marked; and Grandidier calls attention to the fact that the second dentition, puberty, and in females the first appearance and the cessation of the menses, are specially critical periods for these patients. The general correctness of this view is proved by the experience of most of the reported cases. Finally, it is to be noted that with the advance of age there is very generally a gradual decline in the average intensity of the affection, and that accordingly the manifestations of the congenital anomaly are usually found to be most marked in youth, and to become much feebler toward middle life. In exceptional instances, however, the symptoms of hæmophilia recur again and again with undiminished intensity up to old age, and even then death may result directly from one of the hemorrhages.

No definite form of *physiological constitution* exhibits a specially marked predisposition to hæmophilia. There is, however, one peculiarity, namely, a certain delicacy and transparency of the skin, together with a superficial position and marked fulness of the subcutaneous bloodvessels, particularly the veins, which is mentioned by many trustworthy observers as so commonly noticeable in bleeders, that we can scarcely deny it a certain causal relation to hæmophilia.

The *Anglo-Germanic race* in both the old and the new world, exhibits a special disposition to the affection, as already mentioned. A similar predisposition, it may be added, appears to exist in the *Jewish race* also, for the disease has repeatedly been noticed among this people in connection with the rite of circumcision, and a considerable number of Israelitish bleeder families have likewise been reported.

The *primordial* causes of hæmophilia and the nature of the influences which originally operate in its genesis are entirely unknown.

But the *exciting* causes of the bleedings, that is, the influences which are able to produce an outbreak when the disposition, however acquired, already exists, are briefly as follows: Cuts, punctures, lacerations, contusions, wrenches, and strains, may all excite *interstitial* as well as *external* extravasations; but it is especially characteristic of bleeders that extremely obstinate and copious external hemorrhages, as well as very extensive interstitial hemorrhages, occur in them, not only after severe wounds and injuries, but also quite commonly after even the most insignificant traumatic accidents. Indeed, it seems as if it were just these very trifling injuries, so harmless in healthy persons as scarcely to attract attention, that are specially dangerous in bleeders; in fact, the mortality statistics of hæmophilia show that hemorrhages result far oftener from very slight than from severe wounds. Thus, simple punctures, the opening of small superficial abscesses, the application of leeches and cups, the extraction of teeth, cutting the frænum linguæ in young children, circumcision, and numerous other trifling operative procedures, have been followed by uncontrollable and ultimately fatal hemorrhages in so large a number of cases that any operation upon these patients, however slight, attended with bleeding, must be considered dangerous. The same is also true of slight accidental wounds of all sorts, such as pin-pricks, cutaneous abrasions, trifling contusions, etc.; for they likewise are very apt to be followed by most obstinate and alarming external hemorrhages, or by very diffuse ecchymoses. But some of these minor wounds are, as a rule,

attended with much more risk than others. For instance, circumcision, the extraction of teeth, and accidental wounds of the head and face are spoken of as exceptionally dangerous in bleeders, while venesection and vaccination are regarded as less hazardous. Still, all clinical observation shows that any traumatic lesion in a bleeder, whatever be its cause or situation, may excite a characteristic hemorrhage externally or interstitially.

Again, the danger from the same kind of wound in a bleeder, for instance, a leech-bite or a pin-prick, is not equally great at all times (Wachsmuth, Martin, Grandidier); thus, it appears that the individual disposition to hæmophilic hemorrhages varies considerably at different times. The critical periods of life for bleeders have already been mentioned. But it must be added that variations in the individual disposition of bleeders to the occurrence of traumatic hemorrhages, result from other causes which have not yet been fully determined. The change of season in spring and autumn, and the sultriness of air preceding a thunderstorm, have been mentioned with some plausibility; the evidence, however, is too imperfect to be conclusive.

Moreover, the occurrence of a traumatic hemorrhage in bleeders, at times, not only awakens a hitherto latent hæmophilia, but also materially aggravates, at least temporarily, the manifestations of an already developed hemorrhagic diathesis. To this almost all writers testify. Virchow, Grandidier, and others, have noticed that after the occurrence of a traumatic hemorrhage the patient is specially subject to the so-called *spontaneous hemorrhages*, those which are external as well as those which are interstitial. But the spontaneous bleedings of hæmophilia may occur independently of such a connection, and may even constitute the initial manifestation of the disease. Concerning them it is to be particularly noted that sometimes the hemorrhage occurs without any known exciting cause—entirely without prodromata, suddenly, as it were of its own accord.

But more frequently the *spontaneous hemorrhages* are preceded by precursory signs. The patient complains, before the hemorrhage, of flushings, of a hot sensation, and of more forcible pulsations in the heart and arteries. The face, especially the cheeks and the lobes of the ears, is markedly reddened, and feels hot; and there is also headache, together with mental excitement and sensitiveness of sight and hearing. The symptoms, however, as a rule, gradually decline, and entirely disappear when the bleeding is once established. These prodromata are obviously to be interpreted as the expression of an increased arterial tension, perhaps also of an abnormal fulness of the entire vascular system; hence the spontaneous hemorrhages thus characterized may properly be distinguished as fluxionary (Virchow), or even as plethoric hemorrhages. Grandidier also has observed that many of these hemorrhages are induced by influences which excite a more forcible action of the heart, such as alcoholic stimulants, mental emotion, and physical exercise, or which suddenly increase the volume of the blood, as for instance, copious drinking.

To summarize the *exciting causes* of the hemorrhages in bleeders: Most frequently they have a *directly* traumatic origin, but they also occur spontaneously, that is, without any kind of wound or mechanical injury. Still, many of even the latter hemorrhages are *indirectly* traceable to the influence of recent wounds, whereby the tendency to spontaneous hemorrhage is considerably increased, or, perhaps, is, for the first time, awakened. But when there has been no antecedent traumatic hemorrhage, the spontaneous bleedings generally manifest a distinctly *fluxionary* character, and are preceded by various symptoms of congestion and plethora. Finally, in rare instances spontaneous hemorrhages occur independently of any obvious cause, with every appearance of actual spontaneity, and must therefore be considered to result from unknown influences. (Immermann.)

SYMPTOMS.—The phenomena of hæmophilia are essentially of a *hemorrhagic* character.

The external hemorrhages that are *traumatic* always occur at the place of injury, which is most frequently situated in the skin and superficial parts. They are usually due to trifling accidents.

The external hemorrhages that are *spontaneous*, or non-traumatic, occur in a majority of instances from the mucous membrane of the nose and mouth, more especially the former, for epistaxis is by far the most frequent form. In 308 carefully described cases, hemorrhage occurred from the nose 152 times, from the gums 38 times, from the intestines 35 times, from the lungs 17 times, with the urine 16 times, from the stomach 14 times, from the female genitalia 10 times, from the tongue 6 times, from the external meatus auditorius 5 times, from the tips of the fingers 4 times, from the scalp 4 times, from the carunculæ lachrymales 3 times, from ulcers of the skin 2 times, from the upper eyelids 1 time, and from the umbilicus long after the healing 1 time. (Immermann.) In very rare instances, among bleeders, hemorrhage occurs into the abdominal and other serous cavities.

The external bleedings, whether traumatic or spontaneous, are almost always capillary, that is, parenchymatous in character. All the descriptions agree that the hemorrhage takes place, as a rule, not from large vessels, but from numerous vessels of the smallest size (capillaries), and from a great number of minute openings, as if from the pores of a compact sponge saturated with a liquid. Nevertheless, the blood is poured out under a comparatively very strong pressure. The danger, however, results not so much from the profuseness of the hemorrhage as from its *persistency;* in fact, it is this obstinate persistence of every hemorrhage, whatever its origin, which is the most important as well as the pathognomonic peculiarity of the bleeder diathesis. Not unfrequently, an originally trifling hemorrhage which there was every reason to expect would soon cease spontaneously, or yield to treatment, persists in bleeders, in spite of all efforts to restrain it, for hours and days and weeks, until extreme anæmia or death is produced. But the tolerance with which bleeders bear the great losses of blood, and the rapidity with which restoration of the lost blood is usually effected, are still more remarkable.

Interstitial hemorrhages, particularly those of an undoubtedly traumatic origin, often constitute the earliest visible manifestations of hæmophilia; they frequently occur during the first few days of life, or even during birth, from pressure or other mechanical injury of the body of the child during parturition. In after-life, interstitial bleedings occur not only as the direct results of injuries, but are also quite often observed in connection with the external hemorrhages, whether spontaneous or traumatic. In such cases, the surface of the body very frequently becomes covered more or less universally with numerous hemorrhagic efflorescences, which indicate the occurrence of multiple interstitial hemorrhages. The usual anatomical seats of the interstitial bleedings of hæmophilia are the skin and subcutaneous connective tissue. The regions most often involved are the back, the fundament, the neighborhood of the trochanters, and the back of the neck; in brief, those parts of the body which are most subjected to pressure from posture. The *spontaneous* interstitial extravasations, however, are most frequently observed in the hairy scalp, the genitalia, particularly the scrotum, and the extremities; more rarely on the trunk and face. The subtegumentary extravasations sometimes are very copious, and constitute veritable hæmatomata. These blood-tumors have been noticed most frequently in the region of the false ribs, on the back; and especially on the inner surface of the thigh, the popliteal region, etc., in the lower extremities. These blood-tumors have varied considerably in size in the

reported cases; many of them were as large as a goose-egg or an apple, while several instances are mentioned of enormous tumefactions, as large as a child's head or larger, which had been produced by trifling contusions, or had apparently arisen spontaneously.

The so-called *rheumatic affections* are also of such frequent occurrence in bleeders, and their immediate relations, as to deserve special mention. The most important of these rheumatic diseases in bleeders are unquestionably the *joint-affections.* They comprise all the grades of arthritic rheumatism, from simple inflammatory arthralgia up to the most copious synovial effusion. But *rheumatic muscular affections* completely resembling, in their clinical features, the ordinary forms of rheumatic myalgia, are met with in bleeders still more frequently than the joint-affections, and very often are superadded to the latter. Besides, those subject to hæmophilia are peculiarly liable to *neuralgic attacks*, which most frequently involve the *dental branches of the trigeminus.* Grandidier mentions the striking frequency with which bleeders suffer from periodic attacks of violent tooth-ache, often independently of any obvious cause such as caries.

Morbid Anatomy and Pathology.—With regard to *anatomical changes*, no apparatus of the body seems to be abnormally affected in bleeders so uniformly as the vascular system (Virchow). Both the older and more recent writers speak of the striking superficiality and abnormal distribution of the cutaneous and subcutaneous veins and arteries, and especially of the abnormal structure and width of the arteries. Thus, in quite a large series of cases, the intima of the smaller and larger arteries (the temporal and radial, the aorta, pulmonary, carotid, etc.), was found to be remarkably thin, and sometimes actually transparent, without any apparent diminution, however, in the elastic retractility of the coats of the vessels (Virchow); while in a certain number of these cases the lumen of the large arteries (aorta, pulmonary, etc.), and of their main branches, was abnormally narrow throughout the entire extent of the vessels (Schliemann, Virchow, Uhde). Very generally, also, where the autopsy was carefully made, the intima of both the large and the small arteries was distinctly seen to have undergone a partial fatty degeneration, quite analogous, as regards its locality and other characters, to the degenerative changes of the inner coat of the vessels in anæmia and chlorosis (Immermann).

There is, however, a second factor which may possibly be of the highest importance in producing the bleedings of hæmophilia—a factor, moreover, which is not dependent upon the configuration of the vessels, but is directly connected with the absolute quantity of the habitual supply of blood. The greater this habitual supply, and the more the vascular apparatus is permanently overfilled in consequence of it, the more readily the clinical phenomena peculiar to the bleeder disease may arise, and the greater will be the tendency not merely to hemorrhages in general, but particularly to those of a profuse and scarcely controllable character. Thus, it may readily be conceived that, in certain instances, the habitual existence of a high degree of absolute plethora may of itself be sufficient to maintain a bleeder disposition, without the intervention of the vascular anomalies above described. Or, in other words, we may suppose that although, in moderate degrees of habitual plethora, hæmophilia requires for its development the concurrence of certain favoring conditions on the part of the vessels—*e. g.*, delicacy of their walls and narrowness of their channels—still, the affection may now and then manifest itself as a clinical form of disease entirely unconnected with the vascular lesions above described (Immermann). The introduction of this second factor, that is, variations in the volume of blood, enables us to account satisfactorily for the fact that the dis-

position of bleeders to hemorrhages, and the severity of the hemorrhages themselves, are usually by no means the same at all times of life, but present all sorts of fluctuations and differences. To this second factor must be added the *habitually forcible contractions of the heart*, of which we have ample evidence in the unusually hard pulse and apex-beat of many hæmophilic individuals, and particularly in the *cardiac hypertrophy* occasionally found at their autopsies.

To epitomize our present knowledge of its *pathology*, we may state that hæmophilia is, in general, a congenital and habitual form of the hemorrhagic diathesis, in which the oft-recurring and easily-induced hemorrhages for the most part owe their extraordinary vehemence, obstinacy, and danger, to an equally congenital and habitual disproportion between the volume of the blood and the capacity of the vascular apparatus, resulting in an abnormal increase of lateral pressure within the vessels. Moreover, in many instances, functional erethism of the heart, as well as cardiac hypertrophy, by inducing a tendency to congestions, affords important aid in producing the hemorrhages themselves, and in imparting to them their abnormal clinical character. Finally, neurotic influences occasionally act as an additional factor by temporarily increasing the habitually congestive diathesis.

Prognosis.—The *ultimate result* of hæmophilia in a great majority of cases is *death*, possibly in the first attack, but usually from one of the hemorrhages in later life. The mortality of the disease is therefore very high, and at the same time very premature, on account of the generally very early outbreak of the diathesis, and its intensity during the first period of life. A very large number of bleeders succumb to the murderous affection in early youth, the rate of mortality between the first and seventh years being particularly excessive, while only a comparatively small proportion of bleeders, suffering from the well-marked and fully developed form of the disease, escapes the constantly-threatening danger of a fatal hemorrhage until the age is reached when the diathesis is frequently observed to abate spontaneously, or to become latent (Immermann). There can be no question, therefore, as to the extremely pernicious character of hæmophilia, especially in childhood and youth. This view is confirmed by the results noted in 212 fatal cases of hæmophilia that were collected by Grandidier. Of the entire number of patients, 121, or more than one-half, died from hemorrhage before reaching the eighth year, and only 24 survived the twenty-second year.

Treatment.—Every precaution should be taken to avoid all kinds of *injury*, and likewise all influences which determine the occurrence of *plethora* and *congestions*. If a tendency to constipation be present, it should be combated with saline cathartics, especially Glauber's salt; and not unfrequently the manifestations of plethora can be palliated by the vigorous use of that remedy when constipation is not present.

The *traumatic external hemorrhages* of hæmophilia always demand immediate interference. Internal medication should always be employed in such cases, as well as local measures. Among the latter, *compression* continued for a considerable time, perhaps for days, is the most reliable. The *actual cautery* rarely suffices, and therefore should not be employed in these cases. The *twisted suture* has in many instances been found of great service, when the wounds were very small, such as leech-bites, or consisted of simple linear incisions, and has but rarely been followed by secondary hemorrhage. To arrest bleeding from the dental alveoli after the extraction of teeth, which is often very difficult, the most effectual plan of treatment consists in applying a tampon saturated with perchloride of iron, and retaining it in place by a piece

of cork, or by a metallic plate fastened to an adjacent tooth, so as to effect permanent pressure for weeks, if necessary—an operation which can be readily performed by any dentist.

Of internal remedies, the most trustworthy are *acetate of lead* and *ergot*, in large doses frequently repeated. The mineral acids, alum, tannin, etc., are less reliable. In every case, therefore, where the hemorrhage is at all serious, either plumbic acetate in doses of two grains every two hours, or fluid extract of ergot in doses of thirty minims every two hours, should be given until either the bleeding is arrested, or symptoms of poisoning ensue. In bad cases both remedies should be simultaneously administered. At the same time restlessness should be quieted by exhibiting opium or morphia. It has not unfrequently happened that this method has succeeded in rapidly arresting the hemorrhage after local measures have proved entirely fruitless. In cases of internal bleeding, we are, of course, compelled to rely on this method exclusively.

The *spontaneous external hemorrhages*, that is, those of non-traumatic origin, when preceded by various symptoms of plethora and congestion, should not be interfered with until the engorgement of the vessels has passed away; for in checking the hemorrhage prematurely, we might do far more harm than good. Otherwise, the plan of treatment is the same as the above.

The *interstitial cutaneous hemorrhages* (petechiæ, ecchymoses, vibices) require no special treatment in bleeders, inasmuch as the loss of blood is inconsiderable; but as to the *subcutaneous interstitial hemorrhages*, that is, the *hæmatomata*, it is of the first importance to protect these tumors from mechanical injury, and to abstain from opening them prematurely by incision or puncture.

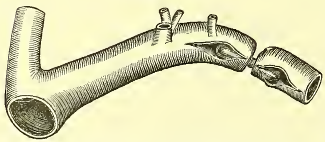
The *rheumatic* complications of hæmophilia are to be treated in the same way as under ordinary circumstances, with the important exception that all remedies should be carefully avoided which may possibly excite hemorrhage. (Immermann.)

Grandidier and others assert that the administration of mercury in any form in the treatment of these rheumatic affections is commonly attended by a temporary aggravation of the hemorrhagic diathesis, and it should therefore be strictly avoided.

The following example of hæmophilia was reported during the late civil war. It will serve to show how much the operation of deligating the main artery is worth in preventing hæmophilic bleedings from gunshot wounds:—

Sergeant Henry B., Co. D, 12th New Hampshire Volunteers, aged 21, was admitted to Emory Hospital, Washington, June 11, 1864, with a gunshot wound of the right shoulder, received at Cold Harbor on the 3d. A minié-ball had entered below the clavicle and passed out at the anterior aspect of the arm, about three inches below the shoulder-joint. There was also a flesh-wound of the upper third of the right thigh. *The patient had a hemorrhagic diathesis, which his father stated was hereditary in the family*—for example, a simple cut of the finger would cause hemorrhage to such an amount as to endanger life. Under these circumstances, and upon consultation, it was decided after his first attack of hemorrhage to ligate the subclavian. The operation was successfully performed on June 17, by Surgeon N. R. Mosely, U. S. V. Strong hopes were entertained of the patient's recovery; but, unfortunately, in addition to his peculiar diathesis,

Fig. 450.



Showing the right subclavian artery divided by a ligature in its third part. The preparation was taken from a bleeder. It has been opened longitudinally, behind, to display the small fibrinous coagula. Spec. 2812, Sect. I., A. M. M. (Posterior view.)

he had a severe cough, which it seemed almost impossible to relieve or arrest temporarily. On the morning of the 29th, while in conversation, the artery gave way, and death from hemorrhage was almost instantaneous. The accompanying wood-cut (Fig. 450) represents the specimen which was obtained at the autopsy. It consists of the right subclavian, of the inferior part of the right carotid, and of the distal end of the innominate. The commencement of the vertebral and of the superior intercostal are also shown, together with the thyroid axis and transversalis colli. There were slight fibrinous exudations on either side of the point at which the ligature cut through.[1]

This patient survived the operation for twelve days. During this period there was no hemorrhage from the original wound. Nevertheless, he died almost instantaneously from a hemorrhage that resulted from the sudden giving way of the ligatured artery. The wood-cut shows that the occluding coagula were very small.

But, upon the whole, the manifestations peculiar to the bleeder diathesis were not very striking in this case. It is, however, not improbable that the privations and hardships attending a soldier's life in the field, by lessening plethora and the tendency to plethoric congestions, had considerably modified the diathesis in his person.

## Intermediary Hemorrhage.

The term intermediary hemorrhage embraces all the effusions of blood from wounds or from wounded bloodvessels which occur in the *intermediary period*, that is, subsequent to the arrest of the primary bleeding or close of the primary period, on the one hand, and prior to the establishment of suppuration on the fifth or sixth day which marks the beginning of the true secondary period, on the other hand. In this interval of time, the phenomena of reaction, whether it be simply normal or more or less strongly inflammatory, present themselves, and thus the intermediary period itself becomes distinctly marked or characterized, and distinguished both from that which precedes and from that which follows it. The hemorrhages which occur in this period are, for the most part, products of the more or less violent reaction and excitement of the vascular system that properly belong to this period; wherefore, the division of traumatic hemorrhages into the *primary*, the *intermediary*, and the *secondary*, is not an artificial classification, but is founded on natural distinctions or differences of an important character. Even those writers who classify the hemorrhages which occur during the reactionary period with secondary hemorrhages, recognize an essential difference between them, which has been well expressed by the late Dr. George McClellan, who says, while speaking of the bleeding which often presents itself in wounds in the course of three or four days after their infliction: "This is called by all writers a secondary hemorrhage, but as there is still an ulterior form of bleeding in some classes of wounds, it is best to qualify this by the epithet *first form of secondary hemorrhage*, or *secondary hemorrhage from reaction*."[2] But, inasmuch as the pathogenesis of these bleedings is totally different from the pathogenesis of the bleedings which occur after suppuration is established, and which are known *par excellence* as secondary hemorrhages, it is beyond a doubt far preferable to designate them as intermediary hemorrhages. Moreover, the term itself will serve to show in most instances, with precision, not only the period when the bleeding took place, but likewise the nature of the forces concerned in its production.

[1] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 540.
[2] Op. cit., p. 187.

Intermediary hemorrhages in general are obviously connected with increased vascular action, and result from the increased force with which the blood is driven through the arteries, during the period of reaction and inflammatory irritation that follows the "shock" of severe wounds, and the depression of profuse primary hemorrhage. During at least three or four days after the infliction of such wounds, it is always possible for a return of the hemorrhage to be effected by the violent reaction or excitement of the vascular system driving out the occluding coagula and forcing open the contracted orifices of the wounded arteries. The following example affords a good illustration of the intermediary as well as of the primary and secondary forms of traumatic hemorrhage:—

A temperate and healthy young man, aged 21, accidentally received in his right armpit the charge of one of the barrels of a bird-gun, loaded with pheasant shot, which produced "an enormous burnt wound in the centre of the axilla, with blackened and burnt edges, passing up along the course of the vessels toward the coracoid process. The powder, wadding, and shot had all been driven into the wound, and the physicians hoped, therefore, that the contusion of the surfaces, in addition to the coagulation, would enable them to prevent a return of the hemorrhage by the pressure of compresses and bandages." It should be stated that the infliction of the wound had been immediately followed by "an enormous hemorrhage," that he had fallen "into complete syncope at the door-step of his father's house," and that "the discharge had entirely ceased under fainting."

"About thirty hours afterward, however, a severe hemorrhage returned from the wound in consequence of vascular reaction forcing off the coagula from the torn vessels. He fainted again almost unto death, and remained several hours exceedingly prostrate, during which period [McClellan] was first called in consultation. As large tents well graduated in the form of compresses had been forced into the wound with styptics, to the total suppression of the hemorrhage," McClellan did not interfere.

"The case progressed very well after that for ten entire days, when, on turning over in his bed at night, a tremendous hemorrhage broke out again. He fainted, and they were able to suppress the bleeding until [McClellan] arrived and secured the subclavian artery just above the upper verge of the inflammatory swelling and engorgement. The sloughs of dead cellular tissue, and shot, and wadding, afterward came away through the original wound in the axilla, along with the suppuration, and the patient got well with a good use of his arm."[1]

In this case the *primary hemorrhage* ceased on the occurrence of syncope; and the wound appears to have been dressed with compresses, retained in place by applying a roller bandage. Nevertheless, the blood coagulating in the wound did not succeed in effectually plugging up the open mouths of the injured arteries; wherefore it happened thirty hours afterward, when reaction supervened, that the increased blood-pressure, or the increased force of the circulation, drove out the plugs of coagula and started the bleeding afresh, thereby causing an *intermediary hemorrhage* of a most profuse character, which, however, again ceased on the occurrence of syncope, and was afterward held in check by strong compression.

Finally, when suppuration was fully established in the wound, and the sloughing tissues had begun to separate, *secondary hemorrhage* ensued, which, however, was suppressed by deligation of the subclavian artery, with probably a continuance of the local pressure; and the young man had the good fortune to recover with a useful arm.

But intermediary hemorrhage sometimes takes place from the great arteries of the trunk, as happened in the following instance, which occurred during the late civil war:—

[1] McClellan, op. cit., p. 191, foot-note.

A soldier, aged 23, received, near Petersburg, Va., on June 18, 1864, a gunshot wound of the right nates, the ball entering the pelvis at the sacro-iliac symphysis, and on the following day he was admitted into the Hampton Hospital at Fortress Monroe. On the 20th hemorrhage from the common iliac artery occurred, three quarts of blood being lost, and on the 21st death ensued. *Autopsy*—The ball was found lodged at the superior sacro-iliac symphysis, and the common iliac artery wounded.[1]

The following case came under my own observation:—

A soldier, aged 37, received, at Spottsylvania C. H., Va., May 18, 1864, a gunshot fracture of the left humerus, for which the arm was amputated at the upper third by the double-flap method. On the 21st he was admitted to Stanton Hospital. On the 22d, profuse intermediary hemorrhage, arterial in character, suddenly occurred from the stump. The stump was immediately opened, and the bleeding was found to proceed from the brachial artery, the ligature having slipped off from it. The artery was again tied on the face of the stump, and the bleeding was permanently arrested. Most unfortunately, however, the patient was attacked with pyæmic pneumonia, and died on June 4.

In this case, intermediary hemorrhage occurred in the stump of an amputated arm, because the ligature slipped off from the end of the brachial artery; it appears that the ligature had been carelessly applied too near the end of the vessel, and that it had not been drawn with sufficient tightness before knotting. In consequence of this inexcusable negligence, the ligature was gradually pushed off from the end of the artery by its pulsations after reaction had taken place.

When secondary amputations of the extremities are performed through inflamed tissues, intermediary hemorrhages of a *parenchymatous* character not unfrequently ensue, as happened in the following example:—

Lieutenant-Colonel Maxwell, aged 22, was wounded at Five Forks, April 1, 1865, by a conoidal ball, which opened the left knee-joint. An attempt was made to save the limb, but suppurative inflammation ensued, and the thigh became infiltrated with purulent matter between the muscles, as high as the apex of Scarpa's triangle. On April 17, amputation at the middle of the femur, by the circular method, under ether, had to be performed, and the stump was dressed with cold water. On the 18th it was observed that hemorrhage continued, although twelve ligatures had been applied, and that altogether about eight ounces of blood had been lost. The stump was then opened, and liquor ferri persulph. fortis was applied with a camel's-hair brush to the whole surface of the wound, which was also left open and exposed to the air for about fifteen minutes; this proceeding entirely checked the sanguinolent oozing. The patient ultimately made a good recovery.[2]

Notwithstanding that all the arteries of appreciable size had been tied in this case, when reaction came on, bleeding took place from the capillaries of the stump, because they had lost the ability to spontaneously contract, and thus close their open mouths. Moreover, this paralysis of the muscular coats of these vessels appears to have been caused by the inflammatory process, which spread from the wounded knee-joint upward into the thigh.

But whenever the arteries are not completely nor transversely divided, but are only cut into or punctured, intermediary hemorrhages are very common. Sometimes a temporary arrest of the bleeding can be repeatedly effected in such cases by coagulation, contraction, and syncope, or by the application of pressure, and still, at every recovery or return of vascular power and excitement, the bleeding will be reproduced. The next two examples are in point:—

[1] Med. and Surg. History of the War, Second Surg. Vol., p. 333.
[2] U. S. Sanitary Commission, Surgical Memoirs, p. 176. New York, 1870.

Dr. Robert Battey ligatured the common carotid artery, in a man, for the relief of *repeated hemorrhages* following a deeply incised wound near the angle of the jaw, in the subparotid space. Tendency to syncope, following the loss of blood and the tying of the artery, was noticed for several days. Facial paralysis also appeared, but afterward subsided, and the man's health was subsequently entirely restored.[1]

The hemorrhage appears to have recurred in this case whenever the reaction rose high enough to give the arterial pulsations a force sufficient to drive out the plugs of coagula which temporarily restrained the bleeding.

A soldier, aged 25, was wounded at Missionary Ridge November 25, 1863, by a ball which entered anterior to the left angle of the lower jaw, making a ragged opening nearly one inch long, and, fracturing that bone, passed downward and to the right under the tongue, cutting the floor of the mouth, and escaping from the right side of the neck behind and a little below the great cornu of the hyoid bone. On the evening of the 29th, intermediary hemorrhage from the mouth and the orifice of exit suddenly occurred, and between three and four pints of blood were lost before the hemorrhage was suppressed by tying the right common carotid artery, just above the omo-hyoid muscle. The hemorrhage was supposed to proceed from some wounded branches of the lingual artery. On December 2, the hemorrhage recurred both morning and evening; about midnight it again recurred with considerable force, necessitating the ligation of the left external carotid artery. After that the bleeding did not return, and the patient did well.[2]

In this case, too, the intermediary hemorrhage appears to have been caused by the bursting open of traumatic orifices in arteries which had been imperfectly plugged up with coagula, the reopening of these orifices being produced directly by an increased force in the arterial current of blood that was due to the reaction. Moreover, the hemorrhage recurred a number of times, and continued to recur until the circulation in both lingual arteries had been controlled by the application of ligatures.

Treatment.—I have repeatedly seen an intermediary hemorrhage produced by leaving a coagulum in the wound, which there acts like a warm sponge, and constantly promotes a tendency to hemorrhage during the reactionary period. In such cases, the coagula should always be thoroughly removed by the fingers, or by a suitable sponge: and the contact of fresh air will then often stop the bleeding. At all events, the surgeon can then find out the situation of the bleeding orifice, and can close it by a ligature or by a well-adjusted compress. Such wounds should always be cleansed with carbolized water, and should be dressed antiseptically. Drainage tubes, likewise, may often be advantageously inserted.

The occurrence of intermediary hemorrhage in the stump of an amputated limb generally makes it necessary to remove the dressings, to open the flaps, and to wipe off the coagula without delay. If the bleeding result from the careless or imperfect ligation of any artery, it should immediately be tied again, and in a secure manner. Likewise any artery that may have been overlooked should be securely tied. If the hemorrhage proves to be parenchymatous, and does not subside on wiping off the clots, the whole face of the stump should be washed with alcohol; in case this fails, the solution of the perchloride or persulphate of iron must be applied with a brush, or on lint, to the bleeding surface, a proceeding which was attended with admirable success in one of the cases related above. Intermediary hemorrhages in stumps always necessitate the employment of drainage tubes and antiseptic dressings.

[1] American Journal of the Medical Sciences, April, 1881, p. 505.
[2] Ibid., July, 1864, p. 276.

Intermediary hemorrhages from wounds where from any cause the bleeding vessel cannot be tied on each side of the aperture, and in the wound itself, not unfrequently require that the main artery should be ligatured as near the wound as practicable, on the cardiac side. This operation was attended with success in two cases related above.

Professor Hamilton says:—

"These intermediary hemorrhages are pretty frequent in military practice, and do not receive the attention they demand. If it were not that surgeons cannot always spare the time, when the number of wounded is very great, to make a very critical search for vessels which do not at first bleed, we would say that such bleedings implied culpable negligence on their part; but, however this may be, the omission to give it prompt and careful attention now, can only be excused on the ground of an extraordinary necessity. Some of these patients, left to themselves, bleed to death; but it more often happens that, in the hope of arresting the bleeding by pressure alone, or by cold applications perhaps, the surgeon entrusts the matter to an attendant, until the track of the wound and the adjacent structures become filled with coagula, which greatly increase the difficulties of subsequent ligation of the vessel; and which coagula, if the bleeding finally ceases, become depots for the formation of pus, thus greatly retarding the final cure. In the case of amputations made on the field, the same observations will apply. The intermediary hemorrhages lift the flaps, and prevent all possibility of immediate union. It is far better in such cases to re-open the wound, remove the clots, and tie the vessels; although it may be somewhat mortifying to the surgeon who made the original dressing, since it is apt to be construed into a reflection upon his skill."[1]

## Secondary Hemorrhage.

By the term secondary hemorrhage we designate all bleedings from wounded vessels which occur subsequently to the establishment of suppuration, that is, subsequently to the fifth or sixth day after the infliction of the wound, and, likewise, all losses of blood occasioned by the spontaneous rupture or opening of the sac in cases of traumatic aneurism. This accident, in general, belongs to the secondary period in the history of wounds, strictly so called, and is closely connected with the processes of suppuration, ulceration, and sloughing, which pertain to that period, but especially with the unhealthy forms of suppuration. It may occur during any part of the secondary period; but, according to the statement of surgical writers, it is more liable to happen between the *seventh* and *twentieth* days, and especially about the *fourteenth* day. Before the seventh and after the twentieth days it is not often met with. I have, however, known several instances in which secondary hemorrhage occurred on the fifth and sixth days, on the one hand, and on the twenty-seventh, twenty-eighth, thirty-first, forty-first, forty-second, sixty-ninth, and eighty-fifth days, on the other.

Causes.—On investigating the clinical history of secondary hemorrhage, we find that it is produced by a considerable variety of proximate physical agencies:—

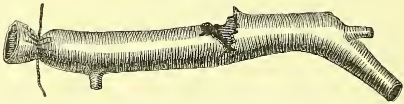
(1) This form of after-bleeding often results from contused wounds and contusions of the coats of arteries. A great many examples have already been mentioned in this article. In such cases, the bleeding is restrained until the bruised portion of the arterial tunics which becomes a slough is separated from the sound portion by a suppurative exulceration, and then the blood immediately begins to escape from the bruised vessel. The following ab-

[1] Military Surgery, pp. 213, 214. New York, 1865.

stract and the wood-cut accompanying it (Fig. 451) afford good illustrations of this topic:—

A soldier,[1] aged 25, was wounded June 3, 1864, by a conoidal ball which entered the left axilla, and lodged at the posterior border of the scapula; it was extracted, and simple dressings applied. On the 15th secondary hemorrhage to the amount of twenty ounces occurred. The wound was filled with lint, soaked in a solution of the persulphate of iron, and a compress applied. On the 16th hemorrhage again occurred, but yielded to strong pressure on the compress. On the 17th the patient was very pale and anæmic, and was suffering much pain in the arm and shoulder. The compress and plug were removed, and the blood gushed out alarmingly. The wound was at once freely dilated,

Fig. 451.



Gunshot contusion of left axillary artery; profuse secondary hemorrhage on the twelfth day; the vessel tied in vain. Spec. 2576, Sect. I., A. M. M.

and the axillary artery tied. The hemorrhage stopped, and at the same time the heart ceased to beat. *Necroscopy*—The axillary artery was found widely opened by sloughing, about the middle of its course, on the side next to the track of the ball. The specimen is represented in the accompanying wood-cut (Fig. 451), which exhibits a large, deep perforation, with jagged edges, involving nearly half the cylinder of the artery, about an inch above the origin of the subscapularis.

The missile which penetrated the axilla in this case was nearly spent, and lodged. In passing, it doubtless struck the side of the axillary artery (where the jagged aperture is shown in the wood-cut), and strongly bruised all its tunics, so that when the slough came away the canal of that vessel was widely opened.

(2) This variety of hemorrhage not unfrequently occurs in consequence of simple ulcerative inflammation, by which the coats of the arteries are perforated and their canals are opened. Displaced fragments of bone, through pressure, not unfrequently cause ulcerations in the walls of arteries, making apertures through which secondary hemorrhages take place. Several instances have already been mentioned. The following example came under my own observation:—

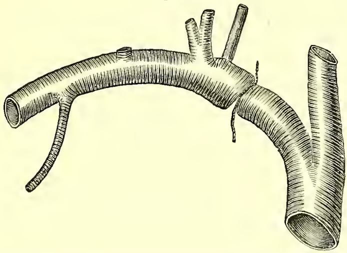
A soldier, aged 24, was wounded at Cold Harbor June 3, 1864, by a conoidal ball, which entered the right ankle in front of the external malleolus, and emerged below the inner malleolus, having fractured the lower end of the tibia and the astragalus. An effort was made to save the limb; on the 12th he was admitted to Stanton Hospital, where this effort was continued. He did tolerably well until August 27, when a profuse flow of arterial blood unexpectedly occurred from the wound, and reduced him very much. Without delay, and as a last resource, I amputated his leg, at the place of election, under ether. On dissecting the amputated limb it was found that the posterior tibial artery was the source of the bleeding; that the pressure of a piece of bone had caused ulceration and sloughing of its walls, and that the piece of bone itself had been displaced and driven against the artery by the missile. The articular surfaces of the tibia and astralagus were extensively comminuted.

A strongly supporting course of treatment was pursued, the patient receiving nutrients, stimulants, and tonics, as required, but these did not enable him to overcome the effects of the bleeding. He died from anæmic exhaustion twenty days after the hemorrhage.

[1] Med. and Surg. Hist. of the War of the Rebellion, First Surg. Vol., p. 554.

The following history and the wood-cut which accompanies it (Fig. 452) furnish good illustrations of the same topic. The operation of ligaturing the subclavian artery in the first part of its course was performed by Assistant-Surgeon S. C. Ayres, U. S. Volunteers:—

Fig. 452.



Ligature of the right subclavian artery within the scaleni muscles for hemorrhage from the subclavian, occasioned by a sharp fragment of bone, which had caused ulceration and perforation of the wall of the artery. Spec. 4729, Sect. I., A. M. M.

A scout[1] was shot on November 15, 1864, while on an expedition. The ball struck the external third of the clavicle, fracturing it, passed obliquely inward and backward, and emerged behind, near the spinal column, having opened the right pleural cavity. On December 14 a severe hemorrhage from the subclavian artery occurred, and this vessel was promptly tied, in the first part of its course, in the following manner: "A triangular flap was made by cutting parallel with the upper border of the clavicle and along the inner border of the sterno-mastoid—the two incisions meeting at the sterno-clavicular articulation. The sternal and part of the clavicular insertion of the sterno-mastoid, as well as the sternal attachments of the sterno-hyoid and sterno-thyroid muscles, were divided and turned backward with the fingers, and the cellular tissue carefully divided upon a grooved director. The par vagum was recognized and drawn inward, and the internal jugular vein outward. The artery was found lying quite deep below the clavicle; with some difficulty the aneurism needle was passed around the artery from below upward and the ligature drawn." The hemorrhage immediately ceased; but the patient sank rapidly, and died in half an hour. "*Autopsy*, twelve hours after death—Body much emaciated. The ball had fractured the outer third of the clavicle and the first rib. It had opened the pleural cavity in its course, and had fractured the spinous processes of the seventh and eighth vertebræ and made its exit on the left side of the spinal column. The hemorrhage from the subclavian was occasioned by a sharp spiculum of bone, which had caused ulceration of the coats of the artery. The right pleural cavity contained a large quantity of bloody serum, such as was discharged from the wound previous to death, and the lung was found completely hepatized. It is probable that a vein was ruptured by the ball, . . . . and that the bloody fluid discharged from the pleural cavity before the arterial hemorrhage occurred was a mixture of venous blood and serum; but from the disorganized condition of the tissues it was impossible to tell which branch had been severed." If the hemorrhage had not occurred, the patient could not, in all probability, have lived many days. The accompanying wood-cut (Fig. 452) shows the terminal portion of the innominate, the lower part of the right carotid, and the right subclavian arteries, with a ligature, *in situ*, upon the subclavian, three-fourths of an inch from its origin.

The following case, likewise, is in point:—

Samuel Steinberger was wounded at Williamsburg, May 5, 1862, by a musket-ball, which entered the left side of his chin, fractured the lower jaw, carried away several

[1] Med. and Surg. History of the War of the Rebellion, First Surg. Vol., p. 546.

teeth, a part of the tongue, and the posterior wall of the pharynx, and lodged. He had extreme difficulty and distress in swallowing food or drink. On the 13th, the missile and several teeth were removed from an abscess above the clavicle. On the 16th, copious hemorrhage from the mouth occurred, and was suppressed by tying the common carotid artery, under ether. On the 23d, secondary hemorrhage again occurred, but this time, however, from the aperture through which the ball and teeth had been extracted, ten days before. An unsuccessful attempt was then made to find the bleeding point; and death occurred from hemorrhage, on the same day. An *autopsy* showed that the transverse process of the third cervical vertebra had been fractured by the missile, and that the vertebral artery had rubbed against a displaced fragment of it until the arterial tunics were worn or ulcerated completely through; hence the last hemorrhage.[1]

The first of the two secondary bleedings which occurred in this case, appears to have proceeded from wounded branches of the external carotid, particularly the lingual artery, and was readily suppressed by tying the common carotid.

But simple ulcerative inflammation may spontaneously occur in the walls of arteries, and open their channels, as sometimes happens in depraved conditions of the organism; for example, those induced by typhoid diseases, by purulent infection, by scrofulosis, and by great losses of blood.

McClellan relates the case of a man who had, as a sequel of epidemic influenza, a critical abscess of one of the submaxillary glands, which, on being lanced, discharged an ichorous sanies. Next day, a violent hemorrhage broke forth, and continued until complete syncope. The bleeding recurred, and McClellan, who was called in consultation, dilated the orifice of the abscess, and, on sponging out the coagula, found that the facial artery had been opened by ulceration. The tissues were so much softened that ligatures cut through them. The actual cautery was then applied to the bleeding orifice, and the hemorrhage permanently ceased. The patient perfectly recovered.[2]

In the following example, the internal carotid artery was opened by spontaneous ulceration, and surgical hemorrhage took place:—

E. Schwartz[3] relates the case of a man, aged 61, who had necrosis of the right angle of the lower jaw, with profuse and very fetid suppuration. One day profuse hemorrhage from the cavity of the abscess occurred; it was arrested by introducing a plug through the mouth. The next day it returned, and caused death. *Autopsy*—The internal carotid artery was found exposed, and infiltrated with ichorous pus; it presented anteriorly an oval aperture, one-fourth of an inch long, about an inch and a half from the bifurcation of the common carotid.

Sometimes the internal carotid artery, or a branch of the external carotid, is spontaneously opened by ulceration in cases of acute abscess of the tonsils, as happened in the following instructive instance:—

Ehrmann[4] reports the case of a young Italian, who entered the hospital with *angina tonsillaris*. On the third day the abscess broke, and immediately half a litre of bright red blood poured from the mouth. Three hours later the hemorrhage recurred, but in less quantity. No pulsation could be felt in the tonsillar swelling. A third hemorrhage, more severe than both the preceding put together, caused the common carotid artery to be ligatured. The bleeding then permanently ceased. There was aphonia, which, however, disappeared in four days; no cerebral disturbance occurred. In six weeks the patient was discharged cured.

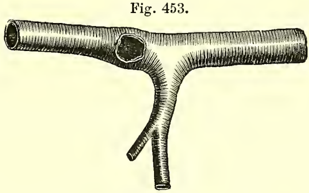
The rational treatment of such hemorrhages consists in tying the carotid; and inasmuch as the source of the bleeding in such cases, whether it proceed from the internal carotid or from branches of the external carotid, cannot be determined during life, deligation of the common carotid must be preferred.

[1] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 355.
[2] Op. cit., p. 200; foot-note.
[3] Gaz. des Hôpitaux, Mai 7, 1874.
[4] Centralblatt für Chirurgie, No. 34, 1879.

(3) Secondary hemorrhages are often developed in consequence of the extension of a sloughing process, especially in unhealthy constitutions, from the adjacent tissues to the coats of the arteries themselves, when they are not primarily injured. The bleeding in such instances occurs on the separation or breaking down of the slough. The next two abstracts, together with the wood-cuts accompanying them (Figs. 453 and 454), most excellently illustrate this topic:—

A Confederate soldier, aged 27,[1] was struck by a musket-ball and captured, June 16, 1864. The missile entered three inches below the left clavicle and emerged at the posterior border of the left axilla. Nothing of importance occurred until July 10, when profuse arterial bleeding from the exit orifice supervened; it was stanched by plugging the tract of the ball with pledgets of charpie dipped in a solution of persulphate of iron, and applying compresses tightly bandaged in the armpit. Bleeding recurred, and the patient died on the 12th. *Necroscopy* revealed a phagedænic condition of the posterior part of the wound, and the subscapular artery had sloughed completely through, or off, at its origin. The accompanying wood-cut (Fig. 453) represents the specimen.

Fig. 453.

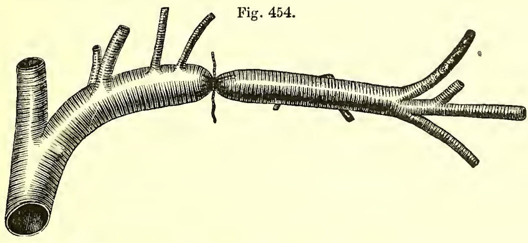


Hemorrhage from the sloughing off of the left subscapular artery at its origin. Spec. 2835, Sect. I., A. M. M. (Posterior view.)

In the next case, also, the subscapular artery was invaded by the extension to it of a sloughing process, in consequence of which there occurred a secondary hemorrhage that proved fatal, notwithstanding deligation of the subclavian artery in the third part of its course:—

A soldier, aged 21,[2] was wounded May 9, 1864, by a conoidal musket-ball, which entered the right axilla, two and one-half inches above the lower border of the pectoralis major, and emerged two inches above the posterior fold of the arm-pit. On the 31st the right subclavian artery was tied at its outer third, for secondary hemorrhage from the injured parts, which were swollen, sloughy, and painful. The patient was feeble from

Fig. 454.



Ligature of the right subclavian artery for secondary hemorrhage; the subscapular artery had been opened by sloughing, and the ulcerous state of this vessel is shown in the cut. Spec. 4331, Sect. I., A. M. M. (Posterior view.)

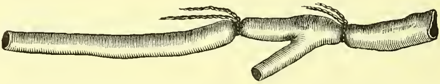
loss of blood; pulse 130; skin hot. The hemorrhage, however, was not suppressed by the operation, for it recurred three times within forty-eight hours; and, on June 2, a branch of the axillary plexus of veins was tied, under chloroform, after cutting through

[1] Medical and Surgical History of the War of the Rebellion, First Surgical Volume, p. 556.
[2] Ibid., p. 539.

the pectoralis major muscle. But death followed three hours after the last, and fifty hours after the first operation. *Autopsy*—The subscapular artery, three-fourths of an inch from its origin, had sloughed; the axillary, and an adjacent vein, had also sloughed. The specimen is represented in the accompanying wood-cut (Fig. 454). There are anomalies in the origin of the vertebral and thyroid axis; and the axillary divides into the brachial and ulnar arteries.

We should also state that this form of after-bleeding is not unfrequently met with in parts that are involved in, and undergoing destruction from, *hospital gangrene*, and that some of the most striking instances of it ever witnessed by surgeons have occurred during the progress of that affection. The following abstract and wood-cut (Fig. 455) furnish tolerable illustrations of this point:—

Fig. 455.



Showing ligations of the radial and brachial arteries for secondary hemorrhage caused by gangrene. Spec. 3645, Sect. I., A. M. M.

A corporal, aged 37,[1] received, June 18, 1864, a gunshot flesh-wound of the upper third of the right forearm. On the 28th he was transferred to Satterlee Hospital. The wound was sloughing; the patient anæmic and despondent. Nitric acid was applied to the wound, and followed by flaxseed poultices; extra diet was prescribed. By July 20, the gangrene having ceased, healthy granulations had arisen, but the patient's despondency continued. On the 23d profuse hemorrhage from the radial artery occurred, and that vessel was ligated. The surrounding tissues being much disorganized and the hemorrhage continuing, a ligature was put around the brachial just above the bifurcation. Next day several minor hemorrhages occurred, and on the 25th the patient died, apparently of anæmic exhaustion. The specimen is represented in the accompanying wood-cut (Fig. 455), and shows the radial artery ligated just below, and the brachial artery just above, the bifurcation.

In all the cases belonging to this category, the bleeding occurs from parts of the arteries where the tunics have not been primarily injured by the missiles, as already stated. The solutions of continuity are entirely due to morbid processes of a peculiarly destructive character. These processes are much more rapid in their progress than simple ulceration. The term *sloughing ulceration* is sometimes employed to represent the less severe, and that of *sloughing phagedæna* the worst instances.

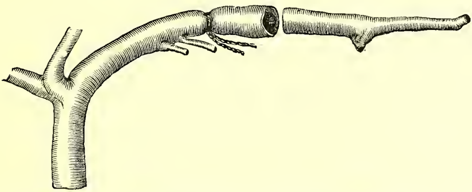
But the secondary hemorrhages which result from sloughing are specially prone to be followed by pyæmia. The accompanying abstract and wood-cut (Fig. 456) will serve to illustrate this point:—

A corporal, aged 30,[2] received, September 19, 1864, a gunshot flesh-wound of the middle and outer side of the left arm and left side of the back, and entered a general hospital on the 27th. The wound was then sloughing. On October 4, 5, 6, and 7, hemorrhages occurred. The first three were controlled by a saturated solution of alum and persulphate of iron, and compresses of lint. The last hemorrhage required the application of a tourniquet to restrain it; during the day the entire hand and arm became excessively congested and inflamed; the axillary artery (left) was then tied in its third part. The patient's general condition was bad; he was much debilitated, having lost in all some thirty-six ounces of blood, and was subject to intermittent

[1] Med. and Surg. Hist. of the War of the Rebellion, Second Surg. Vol., p. 450.
[2] Ibid., p. 442.

fever. He improved for a week, and the wound began to look healthy, when pyæmia set in. On the 22d he died, fifteen days after the operation. *Necroscopy* proved that pyæmia caused death. The right lung contained secondary abscesses, and the right

Fig. 456.



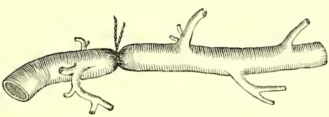
Showing the left axillary artery a fortnight after ligation for secondary hemorrhage from the brachial. Death resulted from pyæmia. Spec. 3679, A. M. M.

pleural cavity was full of pus. The specimen is represented in the accompanying wood-cut (Fig. 456). The axillary artery has been opened transversely, seemingly to show the distal coagulum.

(4) Secondary hemorrhages are not unfrequently produced by the sloughing of the coats of arteries at the points where they have been secured by ligatures. The following abstract and wood-cut (Fig. 457) will serve to illustrate this topic:—

A sergeant, aged 22,[1] received a shot wound at the upper third of the right arm June 4, 1864, the ball passing antero-posteriorly; the wound sloughed, and secondary hemorrhage ensued on the 25th; the axillary artery was ligated under chloroform. On July 1, hemorrhage arose from the axillary, the artery having sloughed at the point of ligation. The artery was then tied again high up in the axilla, by enlarging the previous wound of operation, and without anæsthesia. The patient was exsanguinated, having lost about thirty ounces of blood, and died one hour after the operation. Only the terminal subclavian and upper axillary portions of the vessel, with their branches, are represented in the accompanying wood-cut (Fig. 457).

Fig. 457.



Showing ligation of the right axillary artery in the first part of its course, for secondary hemorrhage caused by sloughing of the artery at the point where it had been ligatured for a previous hemorrhage. Spec. 2545, A. M. M. (Posterior view.)

(5) Secondary hemorrhages are sometimes produced by the liquefaction and breaking down of the coagula and adhesions which have been formed at the mouths of wounded arteries, and by which they have been more or less firmly occluded. When this retrograde metamorphosis of the fibrinous material by which the apertures in wounded vessels are, in general, permanently closed, takes place, it denotes a more or less rapidly deteriorating condition of the general health of the patient, since its occurrence is due to constitutional rather than to local causes.

[1] Med. and Surg. Hist. of the War of the Rebellion, Second Surg. Vol., p. 441.

The following example occurred in my own practice:—

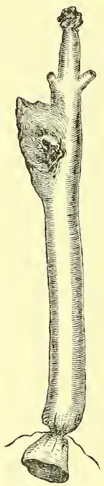
A soldier, aged 27, was admitted to the Stanton Military General Hospital June 4, 1864, for a gunshot wound of the right leg, complicated with a badly comminuted fracture of the fibula, which had been received at Cold Harbor, on May 31. The effort to save the limb was continued. On June 14, secondary hemorrhage (arterial) occurred from the wound, and about ten ounces of blood were lost. The leg was then greatly swelled and inflamed all the way up to the knee. The pulse was small and frequent, and there were other signs indicating the approach of irritative fever; wherefore, the limb was amputated without delay, at the lower third of the thigh, by the circular method, under ether, as affording the patient the best chance of his life.

Examination of the amputated leg showed that the muscles were extensively infiltrated with purulent matter, that the peroneal artery was severed, and that the hemorrhage had proceeded from its proximal end, which had been re-opened through liquefaction of the occluding clot and fibrinous exudation at the mouth of the vessel.

The patient did well for a few days; but unhappily he was then seized with pyæmia, and died from that disease, eleven days after the operation.

The following abstract and wood-cut (Fig. 458) will serve to still further illustrate this subject in a useful manner:—

Fig. 458.



Showing ligation of right carotid artery, and rugose, ulcerated section of external carotid. Spec. 2133, Sect. I., A. M. M.

A soldier was wounded[1] Sept. 20, 1863, by a conoidal ball, which entered below the left zygomatic arch, passed transversely through, and escaped from the right side of the neck below the angle of the lower jaw. On Oct. 2, secondary hemorrhage from the mouth and wound of exit occurred. On the 4th the external carotid was ligated. The patient did well and appeared to be safe until the 12th, when hemorrhage recurred, but was again checked by compression. The wounds were nearly healed; but the patient was greatly enfeebled by repeated losses of blood. On the 23d profuse hemorrhage from the wound of exit again set in, and the right common carotid was ligated, about an inch and a half above its origin; but the patient sank and died on the 25th. The specimen was sent to the Army Medical Museum, and is represented in the accompanying wood-cut (Fig. 458), which shows a ligature on the common trunk, that was applied two days before death, a large coagulum at the bifurcation, but imperfectly indicated, the origins of the occipital and facial arteries from the external carotid, and the rugose, ulcerated extremity of the external carotid that had been wounded.

(6) Secondary hemorrhages are occasionally produced in the stumps of amputated limbs by the non-closure or non-obliteration of the main arteries, even when they have been properly secured by ligatures. In such cases, when a ligature separates and comes away, the blood usually flows out from the unclosed and patulous mouth of the artery in a great stream.

The following very striking example occurred in my own practice:—

A Confederate soldier, aged 27, received a gunshot wound of the right knee-joint at the Rappahannock Station November 7, 1863, and was captured. On the 9th, he was admitted to Stanton Hospital, where the attempt to save his limb was still pursued. On the 18th, however, amputation of the member become necessary, and accordingly was performed at the inferior third of the thigh, by the double-flap method, under ether. After that the patient did well in every respect until December 1, when he began to complain of great pain in the stump, and became agitated and restless. On the 2d, the pain, agitation, and restlessness were

[1] Med. and Surg. Hist. of the War of the Rebellion, First Surg. Vol., p. 393.

increased, and his countenance indicated great suffering. He referred the pain to the stump-bone, particularly the end of it; but he was not feverish, and the stump itself was not swelled nor hot. On the morning of the 3d, at an early hour, the ligature separated from the femoral artery, and secondary bleeding in a great stream immediately ensued. It was soon arrested by digital compression, and did not recur; but, meanwhile, the patient had lost so much blood that he could not be made to rally, and he died, eight hours after the separation of the ligature and the occurrence of the hemorrhage.

*Autopsy.*—All of the stump had firmly united by adhesion, excepting a small part around and in front of the end of the stump-bone. The end of the femoral artery was patulous, not contracted, and without evidence of any effort on the part of the reparative processes of nature to occlude it. It was embraced by the forked extremity of an osteophyte which, springing from the linea aspera, extended horizontally inward along the angle of junction of the flaps. The femoral vein was well sealed up. The medullary tissue of the stump-bone was inflamed, being dark-red in color and of firm consistence, or hepatized, and contained a great number of abscesses which varied in size from that of a pin-head to that of a split pea. This case is fully reported in the volume of U. S. Sanitary Commission Surgical Memoirs, which was prepared by the author, pp. 358, 359.

(7) Secondary hemorrhages very often occur from the distal orifices of severed or ligated arteries, and they result from the imperfect closure of these orifices, the proximal orifices being at the same time well sealed up. During our late civil war many examples of injured arteries were observed, in which there occurred during the secondary period a fatal hemorrhage from the distal end of the divided or ligated vessel. There was an occlusive coagulum on the cardiac side of the ligature; a non-occlusive coagulum, or, in some instances, even no clot at all, on the distal side. Several cases have already been mentioned in which secondary hemorrhage occurred from the distal portion of wounded or ligatured arteries. In the following example, which occurred during the late civil war, there was no clot whatever in the distal portion of the carotid artery, while the cardiac portion was securely plugged:—

Private H. Hutchins, aged 25, was wounded on December 9, 1864, by a conoidal ball, which entered the chin, fractured the lower jaw, and emerged at the back of the neck. On the 18th, violent hemorrhage occurred from the mouth; it was supposed to proceed from the lingual artery, and left the patient almost pulseless. The common carotid was ligatured just above the omo-hyoid muscle. The patient did very well until the 27th, when hemorrhage occurred in the wound of operation, from the distal portion of the artery and the deep jugular vein, and he died on the same day. *Necroscopy* showed an organized clot below the ligature; no clot had formed above the ligature, and the internal jugular vein was opened from sloughing of its tunics.[1]

The clot which forms on the cardiac side of a ligature is usually much larger than that clot which forms on the distal side, and sometimes the distal clot is wholly wanting, as happened in the instance just related.

When arteries of some magnitude are wounded, and the distal ends are not tied, hemorrhage by regurgitation is very apt to occur, as was observed in the following instance of gunshot lesion of the brachial artery:—

A soldier was wounded at Fair Oaks May 31, 1862, by a ball which passed through the posterior part of the upper arm without injury to the bone, but caused an extensive ecchymosis. On June 4, he was admitted to general hospital. On the 10th, free arterial hemorrhage occurred; on removing the clots, the wounded parts were found extensively disorganized, and the brachial artery not accessible. The axillary was then tied high up, and the subscapular also, to prevent subsequent trouble. On the 21st both ligatures came away; feeble pulsations in the radial artery were observed. On the 23d very profuse hemorrhage from the brachial again occurred, which was stopped by compres-

[1] Medical and Surgical History of the War of the Rebellion, First Surg. Vol., p. 420.

sion applied with a pad in the axilla. On July 12 and 13, troublesome hemorrhages still again occurred, and on the 14th the patient died.[1]

The return of pulsation at the wrist showed how completely the circulation in the arm had been restored; two days afterwards, that is, as soon as the tension in the brachial artery was sufficiently strong to expel the clots at the wound, they were pushed out, and then the blood regurgitated freely through the distal portion of the artery into the wound, and a very profuse hemorrhage ensued.

The following example serves well to illustrate the difficulties in treating hemorrhage from wounds of the shoulder, which are sometimes encountered in practice:—

Lieutenant-Colonel Dawson, aged 38, received, June 17, 1864, a gunshot flesh-wound of the left shoulder. The bullet was extracted, and on the 19th he was sent to general hospital at Washington. On the 27th, secondary hemorrhage to the amount of thirty ounces supervened. The operation of tying the axillary artery was resorted to, but the bleeding still continued. The distal extremity was then secured by tying the brachial artery. A few hours later, however, the hemorrhage burst forth afresh, and finally the patient died.[2]

In this case the ligature of the brachial stopped the bleeding for a time by arresting the regurgitation of blood in the brachial artery. From what vessels did the blood escape which finally destroyed this patient? Clearly not from the axillary artery above, nor from the brachial artery below, the points where the ligatures were applied. But a long stretch of the main artery, embracing its wounded part, lay between these two points, and from this some five or six important branches were sent off, namely, several of the thoracic branches, the subscapular, the two circumflex arteries, and the superior profunda; and the hemorrhage which destroyed this patient was doubtless caused by regurgitation of blood through these branches into the main trunk, whence it readily escaped by means of the wound. This result could have been obviated by tying the main artery at the spot where it was injured, with two ligatures, one of them being applied on each side of the aperture in its walls. The axillary artery, therefore, whenever it is the source of secondary hemorrhage, must always be tied in the wound with ligatures placed on each side of the breach in its walls, and in close proximity thereto. When promptly treated in this manner, these hemorrhages give no further trouble.

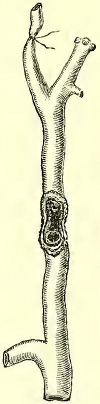
Treatment of Secondary Hemorrhage.—The *prophylaxis* of secondary hemorrhage demands that all wounds, whether the result of accident or of surgical operations, but more particularly those which involve bloodvessels, shall be kept free from purulent matter, by antiseptic treatment and thorough drainage, especially the latter. Otherwise, ulceration and sloughing of the arterial and venous tunics, together with softening and disintegration of the occluding coagula, are very liable to supervene, and secondary hemorrhage to ensue. The following abstract and the wood-cut accompanying it (Fig. 459) illustrate in a useful manner the disastrous consequences which may follow the retention and burrowing of pus in wounds made for the deligation of the common carotid artery:—

A sergeant, aged 21,[3] was wounded Aug. 25, 1864, on the field, by a musket-ball, which entered over the right mastoid process, injured the external ear, and lodged under the

[1] Med. and Surg. Hist. of the War of the Rebellion, Second Surg. Vol., p. 443.
[2] Ibid., Second Surgical Vol., p. 442.
[3] Ibid., First Surg. Vol., p. 393.

skin, a little in front of the auditory foramen. On the 28th he entered the Lincoln Hospital at Washington. The ball had not been extracted, but no symptoms demanded special attention until Sept. 7, when it was observed that the right parotid gland was so greatly inflamed that the patient could with difficulty separate his teeth more than one-fourth of an inch. In the course of the day, an alarming hemorrhage, supposed to proceed from the posterior auricular artery, occurred; it was stopped by compression with lint steeped in a solution of persulphate of iron. On the 9th, an alarming hemorrhage again occurred, which was temporarily arrested, with difficulty, by compression with lint and styptics, until the patient could be taken to the operating room, where, under ether, the right common carotid artery was tied. Coagula were removed, and the missile was extracted from near the angle of the jaw. The bleeding recurred on the 11th and 12th, but ceased spontaneously. On the 18th, there were several recurrences of hemorrhage. On the 19th, the ligature was removed; the face and neck were much swollen. On the 20th, the patient died from hemorrhage. *Autopsy*—Submaxillary gland suppurating; an abscess extended about three-fourths of an inch above and below the place of ligation, and the ends of the artery were covered with pus. The artery from which the hemorrhage issued was not found. The specimen was sent to the Army Medical Museum, and is represented in the accompanying wood-cut (Fig. 459) which shows the termination of the innominate, the commencement of the right subclavian, the trunk of the right common carotid, severed by ulceration at the site of the ligature, and the bifurcation into the external and internal carotid, the calibre represented being one-third of the normal. The ligature on the internal carotid was applied during an experiment upon the cadaver.

Fig. 459.



Showing ulceration of the common carotid attending the separation of a ligature on the tenth day; death from hemorrhage on the following day. Spec. 3252, Sect. I., A.M.M.

It is not improbable that, in cases like the above, the patient might often, perhaps generally, be saved by the employment from the very outset of antiseptic dressings and thorough drainage.

The use of carbolized catgut, or other appropriate antiseptic animal ligature, for the deligation of arteries and veins, will likewise aid much in producing good results, because it does not, in general, cause ulceration, but more or less slowly disappears by absorption, without inducing suppuration; and for this reason such ligatures should be applied in all deligations, whether performed in the primary, intermediary, or secondary period. When suitable animal ligatures are not at hand, those of carbolized silk should be employed, as has already been stated.

Many of the examples presented in the foregoing pages, with a view to illustrate the *pathogenesis* of secondary hemorrhage, also very clearly show some things which should *not* be done for that affection.

(1) The wound should not be plugged with lint soaked by acid ferric salts, or any other so-called styptics, for this treatment never permanently suppresses the bleeding where vessels of any magnitude are opened, and it often does much harm, by permitting the hemorrhage to return again and again in cases where the greatest promptitude of action on the surgeon's part is necessary, in order to prevent the loss of so much blood that fatal anæmic exhaustion must ensue.

(2) The main artery should not be tied at a distance from the bleeding wound, unless nothing else can be done, for in a large majority of cases where arteries are ligatured on the plans of Anel and Hunter, for secondary hemorrhage from open wounds, the bleeding returns sooner or later, and proves fatal.

But how should secondary hemorrhages be suppressed? In the first place,

the wound must be opened, and the aperture whence the blood issues from the injured vessel must, if practicable, be exposed to view by enlarging the original wound or by making fresh incisions, if necessary, and by wiping out the coagula. Oftentimes the search can be materially aided by having an assistant control the flow of blood in the main artery by digital compression, especially in the extremities, and sometimes, likewise, in the neck. "Look your enemy fully in the face," is a motto still more applicable to the management of external hemorrhages than to behavior in battle, for the surgeon has no long-range weapon with which to overcome his adversary. The bleeding vessel having been brought into view, it must be secured with two ligatures, one of them being applied on each side of the aperture in its walls, or to each end of the vessel, if it be completely divided; and the surgeon must sever the artery midway between the two ligatures, with a knife or scissors, in all cases where the original injury has not done so, in order that the two ends may retract, and thus lessen the tendency to a return of the hemorrhage.

The bleeding vessel should likewise be sought for and found without any delay, to the end that infiltration of the surrounding textures with extravasated blood may be avoided, and that the hemorrhage itself may be permanently stopped, if possible, before the loss of blood becomes so great as to cause death by anæmic exhaustion, days and perhaps weeks afterward. The bleeding from small vessels will generally cease on exposing them to the air by wiping off the coagula, and applying cold water with moderate pressure. But to all vessels which continue to bleed, both proximal and distal ligatures must be applied.

When the hemorrhage proceeds from an artery that is inaccessible, as, for instance, the internal maxillary, the main trunk should be tied as near the injured part of the vessel as practicable. In cases where the hemorrhage proceeds from branches of the external carotid which cannot be tied in the wound, the external carotid itself should be ligatured, rather than the common carotid. But the superior thyroid, facial, temporal, and occipital, should always, if possible, be ligatured at the place of injury. Hemorrhage from wounds of the tongue involving branches of the lingual artery should be combated by tying the trunk of that artery above the great cornu of the hyoid bone; and, owing to the great freedom of inosculation across the median plane, it will often be necessary to tie both linguals or both external carotids.

When the vertebral artery is found to be the source of the bleeding, it should be secured by proximal and distal ligatures, if the seat of injury be below the foramina in the transverse processes of the cervical vertebræ; but if the artery be wounded above its passage into these foramina, it should be plugged with a piece of agaric, or a wad of lint, so fashioned as to completely fill the calibre of the artery, on the distal as well as on the proximal side of the breach in its walls.

When an artery of the axilla is found to be the source of the hemorrhage, it should be borne in mind that there is scarcely any other region of the whole body where it is equally important to bring the bleeding vessel into view and to tie it on each side of the gap in its walls. If the axillary artery itself be found wounded, and the circulation be controlled by compressing the subclavian against the first rib, the distal ligature should always be applied first; otherwise, the profuseness of the distal bleeding will very much delay the completion of the operation, and perhaps place the patient's life in peril.

In operating for secondary hemorrhage in the extremities, both lower and upper, it should never be forgotten that the application of a distal ligature is just as important as the application of a proximal ligature, because of the great freedom with which the terminal branches in the extremities inosculate together, as Dupuytren was the first to point out.

Secondary hemorrhage from small arteries in deep cavities, where ligatures cannot readily be applied, may be suppressed by applying the actual cautery.

The employment of carbolized catgut ligatures, antiseptic dressings, and thorough drainage by means of tubes of appropriate size, has already been insisted on with sufficient energy.

## Parenchymatous Hemorrhage.

This form of bleeding did not receive mention until a very recent period. No account of it whatever is given by Guthrie, Hennen, or their predecessors. Stromeyer appears to have been the first to call attention to it.

In cases of parenchymatous hemorrhage, the blood does not issue from the wounded, granulating, or ulcerating part in distinct streams, but seems to escape by a general oozing through minute apertures. We therefore infer that the capillaries constitute its anatomical source, and that it is in reality a capillary hemorrhage. In such cases the blood flows in a steady stream. It does not in general possess the purple hue of venous, nor yet the bright-red color of arterial blood. It is in general not as dark as the former, nor as bright as the latter. It therefore usually has a distinct color of its own, and this, conjoined with the flow of the escaping blood in a steady stream, has led me to correctly surmise, in some instances where these phenomena were present, that the hemorrhage was parenchymatous in character, before the interior of the wound from which it issued had been exposed to view.

Parenchymatous hemorrhage has been met with in the *primary*, the *intermediary*, and the *secondary* periods in the history of wounds; but the causes or pathological conditions upon which its occurrence depends are, for the most part, widely different in each of these periods, especially in the primary and secondary periods.

Parenchymatous hemorrhage has been encountered during the *primary period* in the stumps of limbs just amputated, where the operation has been performed through tissues that had previously been inflamed, and in which the inflammatory process had not yet entirely subsided. Such a hemorrhage is due to the fact that the dilated capillaries which have been severed by the knife in performing the operation, being still paralyzed from the inflammatory process, are unable to close their open mouths by the contraction of their muscular tunics, and that therefore the hemorrhage continues without impediment until it is suppressed by surgical art or by the occurrence of syncope, or until death occurs.

Parenchymatous hemorrhage has been met with during the *intermediary period* in cases of amputation where the mouths of the capillaries have been but feebly or imperfectly closed in the primary period, so that when reaction has come on, with the vascular excitement and increased blood-pressure which attend it, the capillary orifices have been reopened, and capillary hemorrhage has ensued. In such cases, more or less parenchymatous bleeding usually attends the operation itself, and, occasionally, the capillary oozing continues in a minor degree until the advent of the intermediary period, when the capillary bleeding becomes more and more copious as the vascular excitement rises higher and higher.

When parenchymatous hemorrhage occurs during the *secondary period*, it is generally associated with the symptoms of pyæmia, or, at least, with pyæmoid phenomena, and is caused by obstruction of the veins which proceed from the seat of the hemorrhage toward the heart, with coagulated blood or *thrombus*, as was pointed out by Stromeyer. The state of affairs, as far as the circulation of blood is concerned, in a wounded limb, the principal veins of

which are occluded by *thrombosis*, is as follows: The blood injected into the limb through its arteries, being not conducted away through its veins, stagnates, and exhibits a more or less strong tendency to effuse itself from the parts whose capillaries are not strengthened and supported by tissues exterior to their walls. Thus it happens, in such cases, that the capillaries of wounded, granulating, and ulcerating surfaces, not unfrequently give way in consequence of the increased vascular tension, and parenchymatous hemorrhage ensues.

To illustrate *primary parenchymatous hemorrhage*, the following example, which occurred in my own practice, is presented:—

Lieut. C. H. Doerflinger, Co. K, 26th Wisconsin Vols., aged 20, and of excellent constitution, was wounded at Chancellorsville, May 2, 1863, by a conoidal musket-ball, which fractured his left leg, etc. On June 15, he was brought to Stanton Hospital, where the effort to save his limb was continued, although his condition was not favorable. On the 27th, amputation could no longer be delayed, and accordingly it was performed at the lower third of the thigh by the circular method. At the place of operation the tissues were considerably swelled and inflamed. A large number of ligatures were applied. There was also a troublesome oozing of blood, a parenchymatous hemorrhage, from the face of the whole stump. After a time the wound of operation was closed and dressed; but the patient was still retained upon the operating table. In a little while, I was recalled because of a profuse flow of blood through the dressings. These were immediately removed, and the stump opened, in order to find the source of the hemorrhage. It was then seen that the blood did not issue in a distinct stream at any point, but escaped from the parenchyma over the raw surface of the whole stump, by a process of general oozing, and that the hemorrhage in all constituted a current of considerable size. The application of cold water, and even of ice, did not arrest this parenchymatous bleeding, and seemed to retard it but little. Finally, I covered the whole surface of the stump with lint soaked in liquor ferri persulph., and this proceeding speedily suppressed the bleeding. The stump was left open so as to granulate from the bottom, and prevent any collection of purulent matter. The patient slowly recovered.

Another example of primary parenchymatous hemorrhage, which occurred in my own practice, may be found reported in the volume of the U. S. Sanitary Commission Surgical Memoirs, that has been already referred to.[1]

Dr. W. Clendenin has reported a case of primary parenchymatous hemorrhage in a thigh-stump, which proved fatal:—

B. F. Black, Co. A, 6th Kentucky Infantry, aged 23, was wounded at Chickamauga September 19, 1863, by a ball which passed obliquely through his right knee-joint. On October 30, amputation of the limb was performed. No tourniquet was used, and yet, after securing the arteries, profuse hemorrhage of a parenchymatous character took place. This hemorrhage was of the most persistent character; it was, however, finally arrested by applying a strong solution of persulphate of iron, but not until such a quantity of blood had been lost that death ensued the same evening.

*Autopsy.*—In the stump, a large abscess extended as high as the trochanter major, the intermuscular spaces being filled with a sero-purulent fluid. In the femoral vein, just below Poupart's ligament, a fibrinous clot was found, which completely filled up the venous canal at that point. No pus was seen here, nor in any of the veins. The right side of the heart was entirely filled with a fibrinous clot. The liver, lungs, and all other organs were sound.[2]

The femoral vein, in this case, was occluded by a *thrombus*, whose formation had resulted from the presence of an unhealthy femoral abscess. The parenchymatous bleeding which followed the amputation had, therefore, a twofold origin: *First*, the inflamed condition of the tissues divided by the

[1] Op. cit., pp. 241, 413, 414. [2] Ibid., pp. 241, 242.

operation, and the dilatation and paralysis of the capillaries which attend that condition; *Secondly*, the obstruction to the flow of blood from the stump toward the heart, which was caused by the fibrinous plugging or *thrombosis* of the femoral vein. We must, therefore, count thrombosis among the possible causes of primary parenchymatous hemorrhage; and its presence will always make the prognosis very unfavorable.

To illustrate *intermediary parenchymatous hemorrhage*, I shall again call attention to the case of Lieut.-Colonel Maxwell, already presented under the head of Intermediary Hemorrhage. The bleeding occurred in a thigh-stump on the second day after a secondary amputation. It was suppressed by opening the stump, and painting its raw surface all over with liquor ferri persulph. fortis, by means of a camel's hair brush. The patient recovered. Another example of intermediary parenchymatous hemorrhage may be found in a case of secondary amputation of the left arm at the shoulder-joint, performed on August 5, 1864. Hemorrhage to the extent of eight ounces occurred on the 6th. The stump was then opened; "blood apparently oozing from the tissues, and was checked by pressure and Monsel's salt." The patient's general condition was very low, and two days afterwards he died.[1]

To illustrate *secondary parenchymatous hemorrhage*, the following abstract of a case, which occurred in my own practice, is offered:—

Private B. Romig, Co. F, 6th Michigan Cavalry, received on September 23, 1863, a gunshot flesh-wound of the right thigh, at the middle third, and on the inner side. The missile penetrated deeply, and lodged. On the 25th, he was admitted into Stanton Hospital. On October 11th, the symptoms of pyæmia appeared; and, on the 23d, the wounded limb was observed to be œdematous. On the 25th, while the patient was sitting on a chair to have his bed remade, hemorrhage from the wound suddenly occurred to the extent of four or five ounces, and ceased spontaneously. On the 26th, the hemorrhage recurred, and three or four ounces of blood were lost before it again ceased spontaneously. Meanwhile pyæmic rigors appeared, and frequently returned. The patient rapidly failed, and died about three o'clock P. M. on the 26th.

*Autopsy.*—Right lower extremity much swelled and œdematous; on laying open the thigh and groin by incisions along the course of the femoral and iliac arteries, the chain of lymphatic ganglia was found to be very much enlarged in all its component parts. The femoral and other arteries were sound. But the right common iliac, external iliac, common femoral, and deep femoral veins were filled with coagulum (*thrombus*), which in some parts exhibited a quite recent appearance, but in others was more or less disintegrated and softened by fatty transformation. The walls of the thrombosed veins were likewise very much thickened. The thrombosis had obviously caused the hemorrhage.

Not long afterward, another striking example of secondary parenchymatous hemorrhage came under my care at the same hospital:—

Tobias Beaver, a prisoner of war, aged 30, was admitted on November 9, 1863, for a gunshot fracture of the left femur in its lower third, which had been received on the 7th. After some time, the fracture united and the wound of the soft parts healed. At a still later period, osteo-myelitis supervened, in consequence of the lodgment of a part of the missile in the medullary canal. The wound then reopened, and the general health became much impaired. On March 23, 1864, some hemorrhage from the wound occurred. The patient was weak, pale, and anæmic. On the 25th, he had a severe hemorrhage, which was controlled externally by injecting liquor ferri perchloridi; but the thigh swelled rapidly from internal effusion of blood. On the 27th, he died.

*Autopsy.*—The thigh was swelled to twice the normal size. It contained a cavity which extended from the synovial pouches of the knee-joint to the trochanter major, and was full of blood and pus, the quantity being estimated at one quart; the external outlet of this cavity was plugged by a hard coagulum. The superficial femoral vein

[1] Medical and Surgical History of the War of the Rebellion. Second Surgical Volume, p. 444.

was filled with coagulated blood (*thrombus*) from the popliteal to the mouth of the profunda. The subcutaneous connective tissue was highly œdematous, this œdema, as well as the hemorrhage, being obviously due to the obstruction of the venous circulation.

Three additional examples of secondary parenchymatous hemorrhage, which came under my own observation, are reported in the volume of U. S. Sanitary Commission Surgical Memoirs, already referred to.[1]

We have thus mentioned five cases in which parenchymatous hemorrhage occurred during the secondary period. In all of them the bleeding was preceded by general debility, pallor, and loss of flesh. All of them proved fatal. In three instances, the veins were examined after death, and their condition noted; in every instance, the principal veins leading from the seat of the parenchymatous bleeding were found perfectly occluded by coagulated blood, that is, they were plugged up by *thrombosis.* In the remaining two instances, doubtless, the veins were also plugged up by blood-clots. In every one of the five cases, likewise, there were more or less strongly marked symptoms of pyæmia.

To the *obstructive* form of secondary parenchymatous hemorrhage, just described, there is another of some importance which must be added. Capillary hemorrhages may be produced on the surface of granulating wounds by powerful stimuli to the vascular and nervous systems of any kind, as, for instance, venereal excitement, and excess in drinking. The first-named is the common, and the latter an occasional, cause of this additional form of parenchymatous bleeding, which may occur during the secondary period in the history of wounds or surgical operations.

Scorbutic Parenchymatous Hemorrhage.—Scurvy essentially consists of an alteration in the constitution of the blood, which leads to an effusion from the capillaries into the various tissues of a fibrinous liquid, usually deeply colored by red corpuscles.

The passive hemorrhages which take place from the gums, nose and ears, stomach, and bowels, and occasionally from the lungs and bladder, in cases of scurvy, are usually capillary hemorrhages.

The sanguinolent effusions on the free surfaces of sores or ulcers, which impart to them the peculiar aspect termed "scorbutic," are also poured out from the capillaries, and therefore they appear to ooze out from the parenchyma at the base and margins of these sores or ulcers.

When scorbutic persons are wounded, the more or less copious oozing of a sanguinolent liquid from their wounds, or parenchymatous hemorrhage, is not uncommon in the primary, the intermediary, and the secondary periods, but especially in the first two of these. Boyer relates a case where it occurred in the secondary period:—

I amputated (he says) the middle finger of a man, aged 50, for caries in consequence of whitlow. The collateral arteries were tied; the ligatures came away on the seventh day; no hemorrhage followed. Shortly afterward, however, the lips of the wound became bloated, black, soft, and spongy, and bled freely on the slightest touch. From this time the patient experienced every day considerable hemorrhage, to which the ligature and compression were opposed in vain. The bloated appearance of the wound, the spongy state of the gums, the violet spots which appeared on several parts of the body, especially the legs, left no doubt of the existence of scurvy. The patient was then placed upon a strongly antiscorbutic plan of treatment; the hemorrhage soon ceased, and he rapidly recovered.

[1] Op. cit., 245–248.

Treatment of Parenchymatous Hemorrhage.—The primary and intermediary forms of parenchymatous hemorrhage can almost always be promptly suppressed by applying the solution of the persulphate or the perchloride of iron to the bleeding surface, by means of a camel's hair brush, or a piece of lint, as already shown above. In the absence of these styptics, it is highly probable that the primary and intermediary forms of parenchymatous hemorrhage, in open wounds, may be arrested by the application of hot water to the bleeding surface. To be of use the water must be hot enough to coagulate albumen, that is, its temperature must be not less than 160° Fahr. Should this proceeding fail, the actual cautery may be necessary.

When parenchymatous hemorrhage occurs in the secondary period, in consequence of thrombosis and pyæmia, there is but little hope of saving the patient. If the application of styptics and pressure does not stop the hemorrhage, the surgeon may amputate the bleeding member, or tie its main artery. Upon this point Stromeyer says: "A single amputation, practised on this account, proved rapidly fatal; the ligature of the chief artery had but temporary success; the extraction of extensive loosened sequestra sometimes effected a temporary stoppage of the hemorrhage, but death followed from pyæmia."[1] The results of my own experience in this regard are no better. In some cases, doubtless, it is preferable to amputate; in others, to tie the main artery. If the patient be not already much reduced by systemic disease, and especially if pyæmia has not yet appeared, it is better to amputate; but if the patient be very low, or affected with pyæmia, it is better to ligature the main artery.

When parenchymatous hemorrhage results from venereal excitation or excess in drinking, the bleeding may be promptly suppressed by the application of iced water or of the acid salts of iron, in solution, to the part whence it proceeds. The main point, however, in the treatment of such cases, is to prevent a recurrence of the hemorrhage by meeting the causal indication, that is, by removing or making inoperative the causes which produce it.

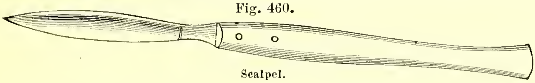
Scorbutic parenchymatous hemorrhage must be treated by freely administering antiscorbutic remedies, such as the juice of scurvy-grass, limes, and lemons, together with acidulous fruits and fresh vegetables for food, as well as milk and the juice of raw beef.

## Deligation of Arteries.

The instruments required for the ligation of arteries or veins, in their continuity, are a scalpel, forceps, grooved director, silver probes, artery-needles, and ligatures.

The ordinary scalpel (Fig. 460) is best adapted to the dissection, and the

Fig. 460.



Scalpel.

broad, thin, end of its handle can be employed to separate the connective tissue, the layers of fascia, and other parts, where it is not desirable to use the cutting edge. The forceps (Fig. 461) should have delicate, accurately-fitting teeth, and the blades, while not too broad, should be so stiff as not to bend when closed and locked, on making traction. Not unfrequently, a second

[1] Gunshot Fractures, p. 35, Am. ed., 1862.

Fig. 461.

Liston's artery forceps.

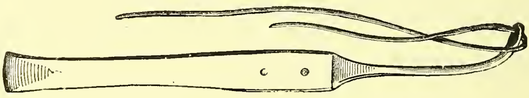
pair of forceps is also required. One, at least, of the silver probes (Fig. 462) should have a flattened and eyed extremity.

Fig. 462.

Silver probes.

Of artery-needles, among the best is Mott's "American aneurism needle" (Fig. 437, p. 240), especially for ligaturing deeply seated arteries. It consists of two sections, namely, a straight handle and a curved extremity, the latter of which is screwed on to the former. The curved extremity, or point of the needle, has two eyes; when used, the second eye is threaded with the ligature; the point of the needle is then gently passed under the artery, and, as it emerges on the opposite side, the blunt hook is inserted into the first eye, whereby the point is securely held until the handle is unscrewed, when the point is drawn through with the ligature. There are, however, several forms of artery-needle which may be reckoned as useful instruments; three of them are represented by the accompanying wood-cuts (Figs. 463, 464, 465).

Fig. 463.



Plain American aneurism needle.

Fig. 464.

Syme's aneurism needle.

The curved point of Mott's artery-needle is sometimes liable to become loosened, and may then turn in the wound while it is being passed around the artery. To obviate this difficulty the instrument represented by Fig. 465 has been devised. The shaft is hollow, and receives a steel rod, having a button-shaped head for convenience in turning it. The lower end of the rod terminates in a male screw, destined to work in a female screw in the upper end of the curved point. The shaft is provided at its lower end with two triangular teeth, and the upper end of the curved point with two correspond-

ing triangular depressions, as shown in the drawing. The two parts of the instrument being placed in relation with each other, the screw is projected,

Fig. 465.

Improved American aneurism needle.

and two or three turns effectually lock the parts together. After the point of the needle has been passed under the artery, and while it is held by the hook, two or three reversed turns of the screw disengage the curved extremity containing the ligature, with which it is then drawn through.

For ligatures, carbolized catgut, prepared by Mr. Lister's improved method, is preferable to every other kind of thread. When from want of suitable animal ligatures it is necessary to use silk ones, they should be carbolized by soaking them for half an hour in a mixture of melted wax and carbolic acid.

The patient must be placed upon a firm bed or upon a table, and the surgeon takes a position usually on the outer side of the limb or part to be operated on; one assistant administers the anæsthetic, a second assistant takes a position where he can compress the artery on the proximal side, if by any accident it should be wounded, or if the ligature should cut through its tunic; a third uses the sponges, and a fourth manages the retractors.

It is important to guard against wounding the superficial veins; wherefore their position should be defined before commencing the operation, which can readily be done by applying pressure on the cardiac side of the point at which the incision is to be made.

General Rules for Exposing and Ligating the Principal Arteries in their Continuity.—I. The operator must, before commencing the operation, call to mind the exact anatomical relations of the parts involved in the operation.

II. The direction and length of the cutaneous incision is then to be determined. It is expedient to mark this out upon the skin with ink or chalk.

III. The body is brought into the position most advantageous for the operation, and into the best light.

IV. The *cutaneous incision* is made by keeping the skin upon a stretch with the fingers of the left hand, while the scalpel cuts through the whole thickness of the skin from one end of the incision to the other; or, if the artery lie immediately under the skin, by pinching up a transverse fold thereof with the fingers, and cutting it through with one stroke of the knife, either from without inward, or by transfixion from within outward.

V. Pinch up the *fascia* carefully with the forceps, nick it with the scalpel applied horizontally, and incise it freely on a grooved director introduced beneath.

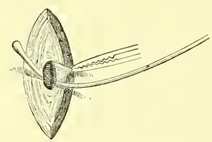
VI. After the edge of the *muscle* is laid bare, which is the *anatomical guide* to the artery, very little use should be made of the knife. With his fingers, or the handle of the scalpel, the surgeon can readily separate the connective tissue so as to fully expose the sheath of the artery; and by so doing he will be much less troubled with oozing of blood or hemorrhage from small vessels, and be enabled to see the principal artery much more distinctly, than if he should use the knife in the deep parts of the wound. (Mott.)

VII. As soon as the *sheath of the artery* is exposed, the operator seizes it with his forceps and raises it into a small cone. He lowers the handle of his

knife so far sidewise and outward that the flat surface of the blade is turned toward the artery, and then divides the cone, flatwise, just beneath the forceps, thus opening the sheath of the vessel. By repeating this procedure, he can open the arterial sheath to any desirable extent. But denuding the artery to any considerable extent of its filamentous structure, must, by robbing the vessel of its connecting media, always be adverse to reparative changes. In fact, if the artery be detached too far from its sheath, it will be liable to slough, and secondary hemorrhage to ensue at the seat of ligation. The sheath should, therefore, be opened no further than is necessary to permit the needle to enter it and pass around the vessel.

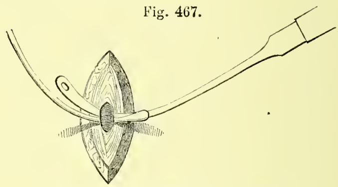
VIII. As soon as the sheath is sufficiently opened, Mott's or the improved American aneurism needle is introduced, and carefully passed around the artery, but always from the side where the vein lies; the handle is then detached by unscrewing it, and the curved point together with the ligature is drawn through. Or, a bent probe is carefully passed around the vessel whilst a pair of forceps keeps the sheath upon the stretch (Fig. 466).

Fig. 466.



Introducing the probe. (Esmarch.)

Fig. 467.



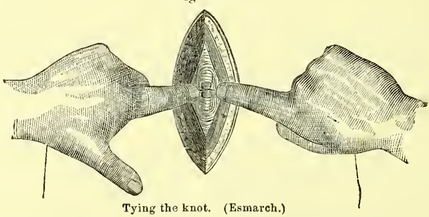
Introducing the aneurism needle. (Esmarch.)

IX. By means of the probe, a track is made, through which a narrow aneurism needle (Syme's or the plain American needle), with an eye at the point, is passed in an opposite direction (Fig. 467).

X. The probe is then removed; the eye of the needle being threaded with a strong ligature of carbolized catgut or carbolized silk, the needle itself is withdrawn, and the middle of the ligature remains lying beneath the artery.

XI. The ends of the ligature are tied together with a square or reef knot, and without pulling on the artery. The knot must be drawn together with the tips of both index fingers at the bottom of the wound (Fig. 468).

Fig. 468.



Tying the knot. (Esmarch.)

XII. It is advisable to tie the larger arteries with two ligatures, and to divide the vessel itself midway between them, so that both ends may retract within the sheath.

Ligation of the Innominate Artery.—*Surgical Anatomy.*—The innominate is the first and largest of the great branches which issue from the arch of the aorta. In length it varies from one inch and a half to one inch and three-fourths. It arises from the right superior portion of the arch of the aorta, in front of the left carotid, and passes in an oblique direction upward, outward, and backward, to the superior margin of the right sterno-clavicular articulation, where it divides into the right common carotid and right subclavian. By extending the neck, the innominate can be drawn up and made more superficial.

It is in relation on its right side with the right vena innominata, right pneumogastric nerve, and the summit of the right pleura; on its left side, with the left carotid artery and a remnant of the thymus gland; behind, with the trachea; in front, with the inferior thyroid vein and the left vena innominata, a remnant of the thymus gland, the origins of the sterno-thyroid and sterno-hyoid muscles, and the sternum.

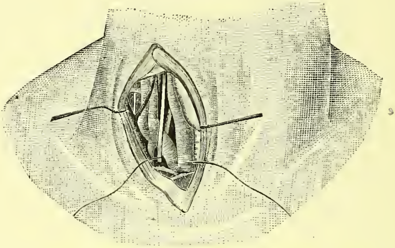
*Mott's Operation.*—Place the patient on his back, with his shoulders slightly raised, his head well thrown back, and his face turned to the left side. The operator, standing on the patient's right side, makes an incision two and one-half or three inches long, half an inch above and parallel to the top of the sternum and the inner part of the right clavicle, through the skin, superficial fascia, and platysma myoides, commencing over the trachea, and ending over the sterno-cleido-mastoid muscle. Another incision of the same length is then to be made along the anterior border of the sterno-mastoid muscle, until it joins the first where it began over the trachea, at the middle line. The sternal root and most of the clavicular root of the sterno-cleido-mastoid muscle are next separated by a director from the underlying fascia, and then divided by cutting in the line of the first incision, using a finger passed under the muscle as a guide. The angular flap must be turned outward. Pushing the thyroid veins aside, the sterno-hyoid and sterno-thyroid muscles are now to be carefully raised on a director, cut across, and drawn inward. A little scratching with a probe or handle of the scalpel will disclose the sheath of the common carotid artery, pneumogastric nerve, and internal jugular vein. Next open the sheath of the carotid, and trace the artery downward to the innominate. Separate the pneumogastric nerve from the carotid, draw it with the internal jugular vein outward, and the carotid inward, toward the trachea, and expose the subclavian artery. In uncovering the innominate, the utmost pains must be taken to avoid injuring the right and left innominate veins. Pass the needle from below upward and inward, taking especial care to avoid wounding the pleura.

Dr. Valentine Mott, of New York, who was the first to ligature the innominate, operated by the method just described, in May, 1818. The patient, however, died on the twenty-sixth day from secondary hemorrhage.

*Sédillot's Operation.*—The brachio-cephalic trunk (says Sédillot) can very easily be reached by following another procedure which I have applied to that artery (Fig. 469), to the primitive carotid, to the commencement of the subclavian, and to the principal branches which issue from it, such as the inferior thyroid and the vertebral. To execute this procedure, make an incision two inches and a half or three inches in length through the integuments, along the interval which separates the sternal and clavicular attachments of the sterno-cleido-mastoid muscle. This interval is distinctly marked by a depression above the sterno-clavicular articulation. Separate the internal from the external portion, while the head is slightly flexed in order to relax the muscle; then, by turning over the sterno-hyoid and sterno-thyroid muscles inside, or by dividing them on a grooved director, which is preferable, one can perceive at the bottom of the wound

the innominate, the common carotid, the pneumogastric nerve, and its branch the recurrent laryngeal; and more externally and above, the phrenic nerve,

Fig. 469.[1]

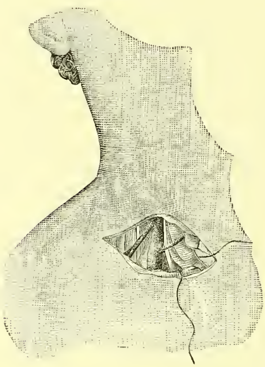


Showing Sédillot's method of tying the innominate artery. (Sédillot.)

the internal jugular vein, the trunk of the subclavian, and the origins of the vertebral, inferior thyroid, and internal mammary arteries.[2]

This procedure enables the surgeon to judge of the condition of the vessels on which he operates, to modify his manœuvres according to their pathological state, and to expose, ligate, and divide between the two ligatures one or several arteries, to assure the success of his operation.

Fig. 470.



Showing Manec's plan of tying the innominate artery. (Sédillot.)

*Manec's Transverse Operation.* — Make an incision 9 centimetres ($3\frac{1}{2}$ inches) in length, extending from a point midway between the two sterno-mastoid muscles, toward the right shoulder, $1\frac{1}{2}$ centimetres, (about $\frac{3}{5}$ inch) above the clavicle (Fig. 470), through the skin and platysma myoides; then, on a grooved director, divide the sterno-mastoid as far as the incision extends, and likewise, successively, the sterno-hyoid and sterno-thyroid. Isolate the innominate artery with the handle of the scalpel and the director, taking care to avoid the internal jugular vein, and the pneumogastric and phrenic nerves.[3]

*Appreciation.*—The procedures of Sédillot and Manec may appear to be more brilliant; but when we consider the difficulty of performing such an operation during life, and the obstacles caused by the effusion of blood at the bottom of a narrow wound, into which the instruments are with difficulty introduced, we shall recognize, I believe, that Mott's operation is the most prudent and

[1] Permission to copy this wood-cut and many others that follow it, to which his name is attached, has been generously given to the writer by Professor Sédillot, Member of the Institute, etc., for which courtesy it is but just to make this acknowledgment.

[2] Médecine Opératoire, t. i. pp. 240, 241. Paris, 1865.

[3] Ibid., pp. 241, 242.

the most sure, and that it should therefore be preferred. This, too, is Sédillot's opinion.

[The innominate artery appears to have been tied in 23 cases, including that recently recorded by Mr. W. Thomson, of Dublin. With one exception (the case operated upon by Dr. Smyth, of New Orleans), all have proved fatal.]

Dr. Smyth ligatured the innominate one-fourth of an inch below its bifurcation, for traumatic aneurism of the subclavian, tying also the common carotid one inch above its origin. Hemorrhage occurred on the fifteenth, thirty-third, and fifty-first day, and was controlled in each instance by filling the wound with shot. On the fifty-fourth day the bleeding again recurred, and then the vertebral was tied; after that, the case progressed, without interruption, to complete recovery. [The patient survived ten years, ultimately dying of hemorrhage from the aneurismal sac, into which the blood had made its way through the subscapular artery.]

Ligation of the Common Carotid Artery.—This artery was first tied for aneurism by Sir Astley Cooper, in a woman, aged 44, at Guy's Hospital, in 1805.[1] The patient died, however, on the nineteenth day. The same surgeon repeated the operation, in 1808, with success.

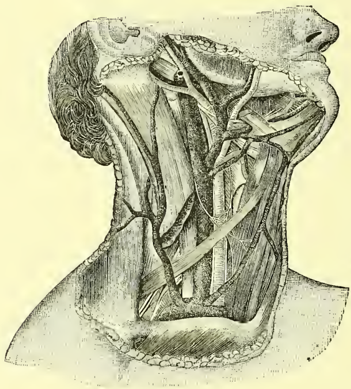
*Surgical Anatomy.*—The right common carotid artery extends from the innominate, that is, from the right sterno-clavicular articulation, to the upper edge of the thyroid cartilage; the left common carotid extends from the highest point of the aortic arch, also to the upper edge of the thyroid cartilage; the left is therefore longer than the right. The relations of both, in the neck, are identical; the direction of each is oblique from before backward, and from within outward, along the external side of the trachea and larynx, in a line drawn from the sterno-clavicular articulation to a point midway between the mastoid process and the angle of the jaw. The sheath of each is derived from the deep cervical fascia, and contains also the internal jugular vein and the pneumogastric nerve, the artery being on the inner side, the vein on the outer side, and the nerve between them. At the root of the neck, the artery lies deeply, and it should not be ligatured at this point, unless absolutely necessary. It is covered, in this part, by the skin and platysma myoides, the superficial and deep fasciæ, the sterno-mastoid, sterno-hyoid, and sterno-thyroid muscles, in front; externally, it is in relation with the pneumogastric nerve and internal jugular vein; internally, with the trachea; behind, with the longus colli and rectus anticus major muscles, together with the transverse processes of the cervical vertebræ. On the right side, the internal jugular vein recedes from the artery; but, on the left, it approaches and often overlaps the artery. The carotid tubercle of Chassaignac, which is the anterior projection of the transverse process of the sixth cervical vertebra, is a precise guide to the artery when the neck is straight. It is from two to three inches above the clavicle (Holmes), and the artery lies in front and a little to the inner side of it.

At the root of the neck the operation may be done in the following manner (Fig. 472):—

[1] Mr. Abernethy, however, in 1798, had tied the primitive carotid, in the case of a man gored in the neck by a cow, the primary branches of the external carotid being torn off, and the internal carotid opened. Finding that he could stop the bleeding by compressing the common trunk between his thumb and a finger within the wound, he placed a ligature around the vessel. The bleeding was suppressed, but the patient died about thirty hours after the operation (Surg. Observations, vol. ii. p. 72, Am. ed.). Mr. Fleming, in 1803, successfully ligatured the primitive carotid for hemorrhage from a self-inflicted wound of the neck (Medico-Chirurgical Journal, vol. iii. p. 50). But, to Sir Astley Cooper the credit is unquestionably due of having first planned and executed this operation, in 1805, for the relief of aneurism.

(1) Place the patient on his back, with his head extended and inclined to the opposite side.

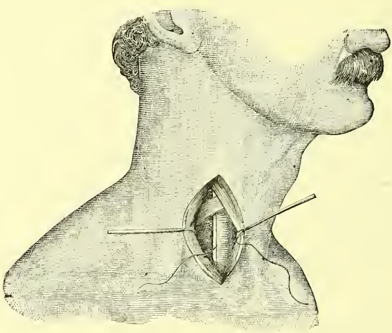
Fig. 471.



Surgical anatomy of the neck. (Sédillot.)

(2) Make a cutaneous incision, two and a half inches in length, between the two heads of the sterno-cleido-mastoid muscle downward to the clavicle,

Fig. 472.



Ligation of the right common carotid artery between the two heads of the sterno-cleido-mastoid muscle. (Sédillot.)

and ending seven-eighths of an inch to the outer side of the sterno-clavicular articulation.

(3) Divide the platysma and deep fascia; widen the interspace between the sternal and clavicular portions of the sterno-cleido-mastoid muscle with the fingers, until the internal jugular vein is visible.

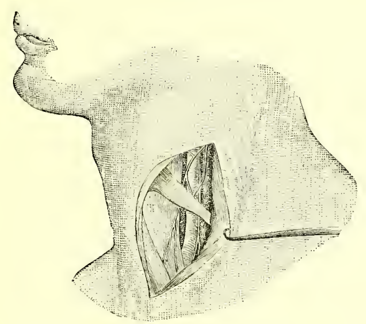
(4) By means of retractors, draw the vein with the clavicular portion of the sterno-cleido-mastoid carefully outward, and the sternal portion, together with the sterno-hyoid and sterno-thyroid muscles, inward; the pneumogastric nerve appears to the inner side of the vein, and the artery lies somewhat further inward and still deeper; the omo-hyoid muscle is seen crossing the vessels at the upper part of the wound.

(5) Open the arterial sheath, and pass the needle from without inward, carefully avoiding the internal jugular vein and the pneumogastric nerve by keeping the point of the needle close to the artery; compressing the vein with a finger at the upper part of the wound will cause it to collapse.

Just below the omo-hyoid muscle the common carotid is much more accessible, and at this point it is not unfrequently ligatured. It is here covered by the skin, the platysma myoides, the superficial and deep fasciæ, the sternal part of the sterno-cleido-mastoid, the sterno-hyoid, and sterno-thyroid muscles; it is obliquely crossed, from within outward, by the sterno-mastoid artery, likewise by the superior and middle thyroid veins, and, lower down, by the anterior jugular; on its external side are the pneumogastric nerve and the internal jugular vein; and on the inner side are the inferior thyroid artery and recurrent laryngeal nerve, which separate it from the trachea and thyroid gland; the descendens noni nerve lies on the sheath of the artery. (Fig. 471.)

To tie the common carotid below the omo-hyoid muscle, proceed thus (Fig. 473):—Place the patient on his back, with his head extended; make an

Fig. 473.



Ligation of the left common carotid artery below the omo-hyoid muscle. (Sédillot.)

incision three inches in length along the inner border of the sterno-mastoid muscle, in the line above described, commencing on a level with the cricoid cartilage, and successively dividing the skin, superficial fascia, platysma myoides, and deep fascia, so as to expose the inner border of the sterno-mastoid muscle; carefully avoid the sterno-mastoid artery and the middle thyroid vein; bend the head forward, draw the sterno-mastoid muscle outward, and the sterno-hyoid and sterno-thyroid muscles inward, by retractors;

expose the anterior belly of the omo-hyoid muscle, and draw it upward; divide the deep fascia, and expose the sheath of the vessels; open it directly over the artery, carfully avoiding the descendens noni nerve, which runs along its tracheal side; press the pneumogastric nerve and the internal jugular vein away from the artery, that is, outward, and pass the needle from without inward, being careful not to include within the ligature the inferior thyroid artery and recurrent laryngeal nerve, which lie behind and on the inner side of the vessel. If the omo-hyoid muscle interfere with the operation, it may be turned aside, or even divided.

Above the omo-hyoid muscle the common carotid artery is still more accessible, and at this point it is very often ligatured. It is covered only by the skin, superficial fascia, platysma myoides, deep fascia, and anterior border of the sterno-mastoid; it is in relation internally with the larynx and pharynx, and, externally, with the pneumogastric nerve and internal jugular vein.

To tie the common carotid above the omo-hyoid, proceed thus:—Place the patient on his back, with his shoulders raised by a pillow, and his head turned to the opposite side; make an incision, three inches in length, commencing a little below the angle of the jaw, in the line above described, along the anterior border of the sterno-mastoid, dividing the skin, superficial fascia, and platysma myoides; then carefully raise the deep fascia on a grooved director, and incise it; avoid injuring the small underlying veins; flex the head to relax the muscles, and draw the margins of the wound apart with retractors; avoid the descendens noni nerve and the superior thyroid artery; open the sheath directly over the carotid; if the internal jugular vein swell up into the incision, compress it in the upper and lower parts of the wound, and draw it outward; pass the ligature from without inward, the point of the needle being kept close to the artery, in order to avoid wounding the internal jugular vein or including the pneumogastric nerve.

The point of election for deligating the common carotid artery is opposite to, or on a level with, the crico-thyroid membrane, and, in performing this operation, the omo-hyoid muscle is often drawn downward; otherwise the steps are identical with those just given.

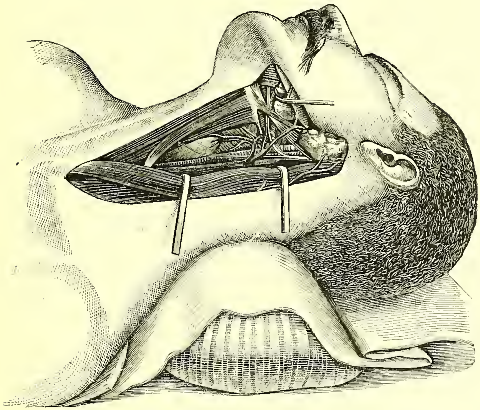
Ligation of the External and Internal Carotid Arteries.—These vessels arise from the common carotid by its bifurcation at the upper edge of the thyroid cartilage, and at their origin the external carotid is more superficial and internal than the other.

*External Carotid.*—The *external carotid artery* ascends almost perpendicularly from its origin to the deep sulcus behind the angle of the lower jaw, occupied by the parotid gland, underneath or through which it passes up to a point between the neck of the lower jaw and the meatus auditorius, where it divides into the temporal and internal maxillary arteries (Fig. 474).

*Relations.*—In front, the external carotid is crossed by the posterior belly of the digastric, stylo-hyoid, and platysma myoid muscles; by the hypoglossal nerve, near its origin; higher up it is situated in the substance of the parotid gland, and is crossed by the facial nerve. Behind, it is separated from the internal carotid by the stylo-pharyngeus and stylo-glossus muscles, the glosso-pharyngeal nerve, and a portion of the parotid gland.

*Operation.*—Place the patient in the position directed for ligating the common carotid. Make an incision from a point midway between the angle of the jaw and the anterior border of the sterno-mastoid muscle, parallel to and three-eighths of an inch in front of the latter, to a point half an inch below the upper border of the thyroid cartilage. The skin, superficial fascia,

Fig. 474.



Showing the surgical anatomy of the anterior superior cervical triangle.

platysma, and deep fascia, having been carefully divided, the last three laminæ on a grooved director, the operator encounters the facial and lingual veins, and not unfrequently one or two lymphatic ganglia. If these veins cannot be readily drawn aside, each of them is to be tied with two ligatures, and divided midway between these. The external carotid artery may now be found, crossed by the hypoglossal nerve, and by the stylo-hyoid and posterior belly of the digastric muscle. It should next be cautiously separated, by means of a director, from the internal carotid artery and internal jugular vein, both of which run closely along its outer side. Pass the needle from without inward between the two carotids, carefully avoiding the internal jugular vein and the hypoglossal nerve. The operation of tying the external carotid artery has proved to be a very successful procedure, for of nineteen cases collected by Professor Agnew, "only one proved fatal from hemorrhage, and none from causes which could properly be attributed to the operation."[1] The terminal branches of the external carotid arteries freely inosculate together across the median plane. When, therefore, the external carotid has been tied for hemorrhage from a wound of its branches, should the hemorrhage return, it is proper to tie the other external carotid. This procedure has, thus far, been uniformly successful.[2]

*Internal Carotid.*—The *internal carotid artery* curves slightly outward from its origin, and then ascends nearly perpendicularly through the maxillo-pharyngeal space to the carotid foramen in the petrous bone. Its cervical portion is in relation, in front, with the stylo-glossus and stylo-pharyngeus muscles, the glosso-pharyngeal nerve and the parotid gland; externally, with the internal jugular vein, the glosso-pharyngeal, pneumogastric, and hypoglossal nerves; internally, it is in relation with the side of the pharynx,

[1] Principles and Practice of Surgery, vol. i. p. 636.
[2] American Journal of the Medical Sciences, October, 1873.

the tonsil, and the ascending pharyngeal artery; and, posteriorly, with the rectus anticus major, the sympathetic nerve, the pharyngeal and laryngeal nerves, which cross behind it, and, near the carotid foramen, with the glosso-pharyngeal, pneumogastric, and lingual nerves, and partially with the internal jugular vein.

*Operation.*—The internal carotid artery may be ligatured through the incisions just directed for tying the external carotid; the latter vessel being drawn forward, and the internal jugular vein being drawn backward, the point of the needle is cautiously insinuated underneath the artery from without inward, its movements being directed by the index finger of the free hand, and extreme care being taken that no structure besides the artery is embraced within the ligature.

Or, make an incision along the inner edge of the sterno-mastoid, three inches in length, from the angle of the jaw to the cricoid cartilage, through the skin, platysma, superficial and deep fasciæ; the inner border of the sterno-mastoid muscle now appears; cautiously separate the connective tissue, draw the sides of the wound apart, and the artery is exposed; draw the digastric muscle and hypoglossal nerve upward, and the internal jugular vein outward; the external and internal carotid arteries may now be ligatured both together, or either of them separately (Fig. 474).

In 1851, Keith, of Aberdeen, Scotland, tied the internal carotid artery with one ligature, on Hunter's plan.

In July, 1869, Dr. A. T. Lee, of Kingston, Tenn., successfully secured the internal carotid artery by two ligatures, one being applied on each side of an aperture in its walls made by a stab-wound of the neck. This case has already been mentioned in the section on punctured wounds of arteries.

In February, 1871, Dr. W. T. Briggs, of Nashville, Tenn., tied the internal carotid above and below with success.[1]

In 1874,[2] a case was recorded by Dr. H. B. Sands, of New York, in which he successfully ligatured the internal carotid artery above and below the bleeding point, for secondary hemorrhage occurring ten days after an operation for the removal of the lower jaw, performed in October, 1872.

Ligation of the Superior Thyroid Artery.—This vessel is the first branch of the external carotid, and issues from it one-fourth of an inch below the great cornu of the hyoid bone. It curves downward and inward to the thyroid gland, in a tortuous course. At first, it is superficial, lying in the triangle formed by the sterno-mastoid, digastric, and omo-hyoid muscles. Before entering the thyroid gland, it divides into several branches which pass beneath the omo-hyoid, sterno-hyoid, and sterno-thyroid muscles.

*Operation.*—Place the patient's head in an extended position. Make an incision two inches in length along the inner border of the sterno-mastoid, the centre of which corresponds to the great cornu of the thyroid cartilage. Having divided the skin, superficial fascia, platysma myoides, and deep fascia, draw the sterno-mastoid outward and expose the omo-hyoid muscle, the internal jugular vein, and the common carotid artery. Then search with the director, or with the handle of a scalpel, for the superior thyroid artery, in the deep sulcus between the upper end of the larynx and the great vessels of the neck, where it is easily found and readily ligated. The needle should be passed from above downward.

Ligation of the Lingual Artery.—*Surgical Anatomy.*—This artery is the second branch which issues from the front of the external carotid. It

[1] American Journal of the Medical Sciences, January, 1879, pp. 142, 143.
[2] New York Medical Journal, January, 1874.

arises about one-fourth of an inch above the superior thyroid, almost facing the great cornu of the hyoid bone. It ascends obliquely above the level of the latter, then curves abruptly downward and inward, and, passing underneath the outer margin of the hyoglossus muscle, runs parallel with and near to the great cornu of the os hyoides; finally, ascending to the under surface of the tongue, it runs forward in a serpentine course to the tip, under the name of the *ranine artery*, and terminates by inosculating with its fellow of the opposite side.

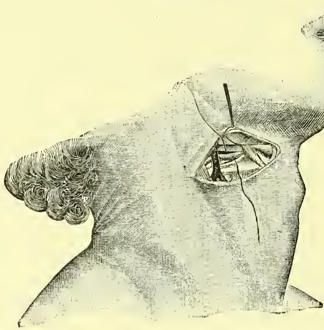
The hyoglossus muscle, underneath which the lingual artery passes, separates it into three portions or surgical divisions, the first being posterior to that muscle, the second beneath it, and the third anterior to it—that is, extending from the anterior margin of the hyoglossus to the tip of the tongue. All its branches, the hyoid, the dorsalis linguæ, and the sublingual, are given off in the second part of its course. The second part or division of the artery, that is, the portion under the hyoglossus muscle, is the part which has uniformly been chosen for deligation.

It is covered by the skin, superficial fascia, platysma myoides, deep fascia, the inferior border of the submaxillary gland, a second fold of the deep fascia which extends beneath the gland and completes its capsule, the facial, superficial lingual, and pharyngeal veins, the stylo-hyoid and digastric muscles, the hypoglossal nerve, and the hyoglossus muscle. It rests upon the middle constrictor of the pharynx, and runs along about one line above and parallel to the great cornu of the hyoid bone. To expose this portion (that is, the second) of the lingual artery, there are three important guides, namely, the glistening pulley of the digastric tendon, the great cornu of the os hyoides, and the hypoglossal nerve; the first two lie immediately below and in front of the artery, the last, immediately above and in front of it, and all three are separated from it by the hyoglossus muscle.

*Operation.*—Place the patient on his back, with his head turned a little to the opposite side and well extended, so as to amplify the space between the hyoid bone and the base of the jaw. Ascertain the position of the great cornu of the os hyoides; then begin the tegumentary incision at the anterior border of the sterno-mastoid muscle, half an inch above a point opposite to the extremity of the great cornu of the hyoid, and, continuing it forward and somewhat downward so as to give it a slight curve with the convexity below, terminate it three-fourths of an inch short of the median line, and half an inch below the base of the jaw (Fig. 475). The head must be rigidly maintained in the same position throughout the operation. Any material change of position, especially flexion, will alter every detail of the procedure. The incisions should all be made in a forward direction, that is, away from the great bloodvessels of the neck, which lie near the posterior end of the wound. The skin, platysma myoides, and the connective and adipose tissue being divided, the first layer of the deep fascia, or the anterior part of the capsule of the submaxillary gland, will appear. Divide it on a grooved director, and the gland will be exposed. With a finger, or the handle of a scalpel, detach the gland from its deep connections, and draw it upward over the jaw with a blunt hook, taking great care that the facial artery and vein, which pass through its substance, are not injured. Divide the portion of the deep fascia constituting the posterior part of the capsule of the gland, and the white shining aponeurosis which loops the digastric tendon to the great cornu of the os hyoides will be exposed, and, likewise, the insertion of the stylo-hyoid muscle. Immediately below them the hypoglossal nerve, accompanied by the lingual vein, will appear, three lines above the cornu of the hyoid, and running across the hyoglossus muscle, forward and upward, toward the middle of the jaw. Detach the nerve somewhat from the hyoglossus muscle by

scratching through the connective tissue which surrounds it, and push it upward out of the way. Fix the os hyoides by inserting a tenaculum into the digastric aponeurosis, then carefully insinuate the point of a director underneath the posterior margin of the hyoglossus muscle, and gently push

Fig. 475.



Ligation of the lingual artery. (Sédillot.)

it along close to the upper border of the great cornu of the hyoid bone, so as to separate the hyoglossus from the middle constrictor of the pharynx which lies behind. Now divide the fibres of the hyoglossus muscle on the director, and the lingual artery accompanied by a vein will be brought into view. Pass the needle from above downward in order to avoid the hypoglossal nerve. Occasionally a few fibres of the stylo-hyoid muscle must also be divided. Some surgeons gradually uncover this artery from before backwards, by raising the fibres of the hyoglossus with a forceps, and incising them with a knife. But at every step of the operation, after opening the superficial fascia, the operator should shape his course by feeling for the great cornu of the os hyoides with a finger in the wound.

*Esmarch's Operation.*—(1) The cutaneous incision is 4 centimetres (about $1\frac{1}{2}$ inches) in length, along the upper border of the great cornu of the hyoid bone. (2) The platysma is divided; the posterior facial vein is drawn outward. (3) The posterior belly of the digastric muscle is exposed; behind and below it, appears the hypoglossal nerve; the submaxillary gland is drawn upward. (4) The hypoglossal nerve runs in front over the hyoglossus muscle, accompanied by the lingual vein; below the nerve and behind the hyoglossus muscle passes the lingual artery. (5) Between the hypoglossal nerve and the great cornu of the hyoid bone the fibres of the hyoglossus are cautiously divided; immediately beneath this muscle lies the lingual artery, accompanied by a vein.

Ligation of the lingual artery is one of the most difficult of all ligations; and, therefore, I have very attentively considered it. Esmarch lays down the steps with clearness and brevity. From the great freedom of inosculation, which exists between the two lingual arteries, it is often necessary to tie both of them to suppress hemorrhage from wounds of the tongue.

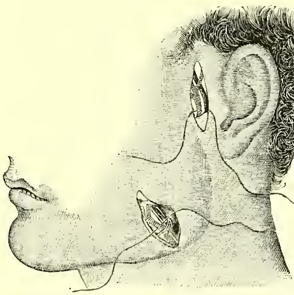
Ligation of the Facial Artery.—*Surgical Anatomy.*—The facial artery is the third branch which issues from the front of the external carotid. It

arises a little above the great cornu of the os hyoides, and passes obliquely to the submaxillary gland, in which it lies embedded. It then curves over the body of the lower jaw, close to the anterior inferior angle of the masseter muscle, ascends to the angle of the mouth, and thence to the inner canthus of the eye, where it is named the angular artery. Over the buccinator muscle its course is tortuous to accommodate itself to the movements of the jaw.

Below the jaw, it passes under the digastric and stylo-hyoid muscles; on the body of the jaw it is covered by the skin, superficial fascia, and platysma myoides, and lies on the periosteum in a groove which is found at the junction of the posterior third with the anterior two-thirds of the body of the bone. The facial vein runs on its outer side. The groove just mentioned is the point usually selected for the deligation of the artery.

*Operation.*—Having recognized the pulsations of the artery, make an incision one inch in length, along its course over the body of the lower jaw, as just described (Fig. 476), through the skin, superficial fascia, and platysma

Fig. 476.



Ligation of the facial and temporal arteries. (Sédillot.)

myoides; separate the lips of the incision, and detach the connective tissue from the artery, which is thus exposed; draw the facial vein and masseter muscle outward, and pass the needle between the two vessels.

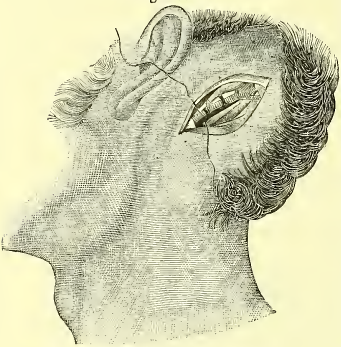
Ligation of the Temporal Artery.—This artery is the more superficial of the two terminal branches of the external carotid. It commences in the substance of the parotid gland, opposite the meatus auditorius externus, ascends almost longitudinally over the root of the zygoma, and, at one inch and a half or two inches above the zygomatic arch, divides into the anterior and posterior temporal branches.

*Operation.*—Having determined the position of the artery by its pulsations, make an incision through the skin, one inch in length, at a point above the zygoma and in front of the ear, then divide the dense connective tissue on a director, and the artery will be exposed. Pass the needle from behind forward, in order to avoid the temporal vein and the auriculo-temporal nerve (Fig. 476).

Ligation of the Occipital Artery.—The occipital artery arises from the external carotid, opposite the facial, passes backward beneath the posterior belly of the digastric, stylo-hyoid, trachelo-mastoid, and sterno-mastoid

muscles, to the occipital groove in the mastoid portion of the temporal bone. It then ascends between the splenius and complexus muscles, and divides into two branches, which are distributed upon the occiput. The hypoglossal nerve curves around this artery near its origin, from behind forward.

Fig. 477.



Ligation of the occipital artery. (Sédillot.)

*Operation.*—To tie the artery near its origin, make an incision along the inner border of the sterno-mastoid muscle, two inches in length, and at the angle formed by this muscle and the digastric. Having carefully divided the deep fascia, expose and isolate the artery, carefully protecting the hypoglossal nerve.

To tie the artery behind the mastoid process, make an incision two inches long, half an inch behind and a little beneath the mastoid process, obliquely upward and backward (Fig. 477). Divide the skin and aponeurosis of the sterno-mastoid muscle, likewise the splenius muscle, to the limits of the wound. The pulsations of the artery are recognized by the finger. It should then be separated from the occipital vein and tied.

If the artery be denuded near the mastoid process, much care must be used not to damage the large mastoid tributaries which hereabout enter the occipital vein, and establish a communication between it and the lateral sinus of the dura mater.

Ligation of the Vertebral Artery.—*Surgical Anatomy.*—This vessel is the first and largest of the branches of the subclavian artery. It ascends through the foramina in the transverse processes of all the cervical vertebræ, excepting the last; then winds backward around the articulating process of the atlas; and, piercing the dura mater, enters the skull through the foramen magnum. The two vertebral arteries unite at the lower border of the pons Varolii to form the basilar artery. Each vertebral artery, with the vertebral vein, lies in front of the cervical nerves in the foramina of the transverse processes of the six upper cervical vertebræ. Before entering the so-called vertebral canal in the transverse processes just mentioned, the artery passes behind the internal jugular vein and the inferior thyroid artery, to the transverse process of the sixth cervical vertebra, ascending between the scalenus anticus and longus colli muscles, in a line drawn from the posterior part of the mastoid process to the junction of the inner fourth of the clavicle with the outer three-fourths of the same.

*Operation.*—Place the patient on his back, with his shoulders depressed and his face turned to the opposite side, and make incisions like those employed in Mott's operation for tying the innominate, that is, make one cut through the skin, superficial fascia, and platysma myoides, $2\frac{1}{2}$ or 3 inches in length, along the anterior border of the sterno-mastoid muscle, and terminating half an inch above the sternum, and another cut of the same depth and length above the clavicle, parallel therewith and half an inch therefrom, to meet the termination of the first cut. Carefully raise and divide the sternal root, together with the anterior part of the clavicular root, of the sterno-cleido-mastoid muscle. Reflect the angular flap, so as to bring into view the common sheath of the

primitive carotid artery, the internal jugular vein, and the pneumogastric nerve. Separate with a finger the cellular connection of the common sheath to the sterno-thyroid muscle, and finally to the longus colli. The head is now to be raised, though still turned to the opposite side, and the common sheath, etc., drawn outward, the sterno-thyroid muscle, etc., being drawn inward, by retractors; separate the connective tissue at the bottom of the wound, and expose the aponeurosis which passes from the scalenus anticus to the longus colli, and the anterior part of the transverse process of the sixth cervical vertebra, that is, "the carotid tubercle of Chassaignac." Then cautiously open the aponeurosis an inch below this point, and the artery is found lying very deep. Pass the needle from without inward. Take especial care to avoid injuring the phrenic and the sympathetic nerves; the "thyroid ganglion" of the latter, and its communicating branches being considerably exposed. Should difficulty be experienced in finding the artery, a finger must be inserted to the bottom of the wound, and search made with it for the "carotid tubercle of Chassaignac," at the extremity of the transverse process of the sixth cervical vertebra, below which the pulsations of the artery may be felt.

From the peculiarity of termination of the vertebral artery, above mentioned, the blood may flow backward, or regurgitate, in it, with almost the same freedom, as it flows forward, or toward the brain; wherefore, this artery, when wounded before it reaches the carotid tubercle, must always be ligatured at the injured part, and with a distal, as well as a proximal, thread, the exposure of the vessel being made by cautiously dilating the original wound.

But, in cases of subclavian aneurism, deligation of this artery in its continuity is not unfrequently necessary because of the great freedom, just mentioned, with which the blood regurgitates in it when the innominate is tied, or the subclavian on the cardiac side of its origin. Thus, Dr. Smyth, in the only successful case of ligation of the innominate, was compelled to tie the vertebral artery as well as the common carotid. Professor Willard Parker, of New York, has tied this artery simultaneously with the common carotid and the subclavian arteries, in a case of subclavian aneurism. Maisonneuve ligatured the vertebral and inferior thyroid arteries for hemorrhage from a shot-wound of the neck, and extracted the missile; the bleeding ceased, but death ensued from purulent infiltration of the spinal canal. Two additional cases in which this artery was ligated have been reported by an Italian surgeon.

Distal ligature of the vertebral artery between the atlas and the axis, as well as between the occipital bone and the atlas, as suggested by Dietrich, would be both difficult in performance and uncertain in result.

Ligation of the Inferior Thyroid Artery.—This vessel arises from the thyroid axis, and ascends obliquely, in a tortuous course, behind the common sheath of the primitive carotid artery, the internal jugular vein, and the pneumogastric nerve, to the inferior part of the thyroid gland, to which it is distributed. It is in relation with the middle cervical ganglion of the sympathetic, the "thyroid ganglion" of Haller, and the communicating branches thereof; they lie in front of it.

*Operation.*—Proceed as for ligation of the primitive carotid artery between the two heads of the sterno-cleido-mastoid muscle (Fig. 472), until the common sheath of the carotid, the internal jugular vein, and the pneumogastric nerve, are brought into view. Then draw the common sheath of these vessels, etc., outward, that is, away from the thyroid gland, and search, just below that body, with a finger in the deep fissure between the common sheath of the great vessels and the œsophagus, for the artery as it ascends behind the

common sheath, obliquely inward, where it should be tied. Pains should be taken to avoid injuring the middle cervical ganglion of the sympathetic, and its communicating branches. The needle should be passed from without inward.

Deligation of both inferior thyroid arteries has been performed a number of times for vascular enlargements of the thyroid gland, but the results have not been of such a character as to warrant a repetition.

However, for hemorrhages from wounds of the neck, as in Maisonneuve's case mentioned above, in which the vertebral was also tied, the operation must be resorted to whenever it appears expedient.

Ligation of the Internal Mammary Artery.—The internal mammary artery is the first branch which issues from the *lower* side of the subclavian artery. It runs directly downward behind the clavicle, on the posterior surface of the costal cartilages, and near the edge of the sternum, until it reaches the sixth intercostal space; there it divides into the musculo-phrenic and superior epigastric arteries. It is accompanied by two veins. The internal mammary artery is crossed in the first part of its course by the internal jugular and subclavian veins, and by the phrenic nerve; in the chest, it lies at first on the costal cartilages and intercostal muscles, and is covered by the pleura behind, but lower it is covered also by the triangularis sterni muscle. Ligation of the external mammary is esteemed easy of performance in the first three intercostal spaces, difficult in the fourth, very difficult in the fifth, and almost impossible in the sixth.

*Goyrand's Operation.*—An incision two inches in length is to be made near the edge of the sternum obliquely from above downward and from without inward, forming with the axis of the body an angle of forty-five degrees. The middle part of this incision should be three or four lines distant from the margin of the sternum, and in the centre of the sternal extremity of the intercostal space. Dividing successively the skin, the cellulo-adipose subcutaneous tissue, and the great pectoral muscle, the intercostal space is exposed. An incision is then to be made in the same direction and over the entire width of the space of the aponeurotic layer which continues the external intercostal muscle and the superficial fasciculi of the internal intercostal. With a grooved director the fibres of the latter muscle are to be separated and torn through, and the artery and its two venæ comites are then laid bare at three lines from the edge of the sternum, separating those fibres from the pleura. Then nothing is easier than to isolate the artery, and pass the needle beneath it.

Goyrand's operation is recommended by Guthrie, and I have no doubt that it constitutes the best method of ligating the internal mammary artery in its continuity.

When, however, traumatic hemorrhage occurs from this artery, it should always be secured at the place of injury by a distal ligature as well as by a proximal ligature; and when the arterial lesion is situated in the fourth, fifth, or sixth intercostal spaces, it will often be advisable to cut out one of the costal cartilages with bone-forceps, either wholly or in part, in order to obtain room for passing a distal and proximal ligature.

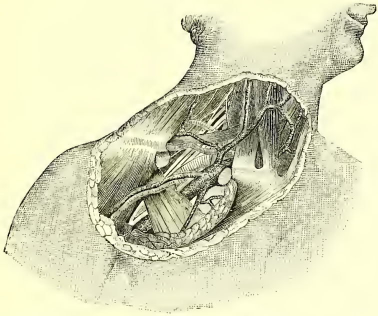
During the late civil war, the internal mammary artery was tied for secondary hemorrhage by Judson and by Bontecou, but in neither instance was the operation successful.

Ligation of the Subclavian Artery.—*Surgical Anatomy.*—On the right side, the subclavian artery issues from the innominate artery; on the left, from the arch of the aorta. The right is, therefore, shorter than the left,

and lies nearer to the anterior wall of the chest; it is also somewhat larger, that is, greater in circumference, because it is a branch of a branch, instead of being a direct offshoot from the main trunk.

The course of each subclavian artery is divisible, for surgical as well as for anatomical purposes, into three parts marked by the scalenus anticus muscle behind which the vessel passes, namely, the *first* part, extending from its origin to the inner margin of the scalenus anticus, the *second* part, lying directly behind the scalenus anticus, and the third part, extending from the outer border of the scalenus anticus to the inferior margin of the first rib. On the right side, the *first part* ascends obliquely outward to the inner border

Fig. 478.



Surgical relations of the subclavian artery and subclavian vein. (Sédillot.) A portion of the clavicle has been removed.

of the scalenus anticus; on the left side, it ascends longitudinally to the inner border of that muscle. On both sides, the *second part* curves outward behind the scalenus anticus. On both sides also, the *third part* passes downward and outward beneath the clavicle, to the inferior margin of the first rib, where it becomes the axillary artery.

*Relations.*—On the *right side*, the *first part* is in relation, in front, with the internal jugular and subclavian veins at their point of junction, and is crossed by the pneumogastric nerve, cardiac nerves, and phrenic nerve. Behind and beneath, it is invested by the pleura; it is also crossed by the right recurrent laryngeal nerve, and by the vertebral vein, and is in relation with the transverse process of the seventh cervical vertebra. On the *left side*, the *first part* is in relation in front with the pleura, the vena innominata, the pneumogastric and phrenic nerves (they run parallel to it), and the left carotid artery. To its inner side lies the œsophagus; to its outer side, the pleura; and, behind, the thoracic duct, longus colli, and vertebral column.

The *second part*, on both sides alike, lies between the two scaleni muscles, and is supported by the first rib. The scalenus anticus separates the artery from the subclavian vein and the phrenic nerve. Behind, it is in relation with the brachial plexus of nerves.

The *third part*, on both sides alike also, is in relation, in front, with the subclavian vein and subclavian muscle; behind, with the brachial plexus of nerves and scalenus posticus muscle; above, with the supra-scapular artery and platysma myoides; and below, with the first rib.

*Operation at the First Part.*—To tie the *right* subclavian on the tracheal side of the scaleni, place the patient on his back, with his shoulders raised and his head turned to the opposite side. Make two incisions, one parallel to the inner portion of the clavicle, and the other along the inner border of the sterno-cleido-mastoid muscle, each three inches in length, and joining at an acute angle. Pass a director behind the sternal attachment of the sterno-cleido-mastoid, and divide it as well as the connective tissue; avoid small arteries and veins in this place, especially the anterior jugular vein. Divide, likewise, the sterno-hyoid and sterno-thyroid muscles on a director. Open the deep cervical fascia by scratching it with a finger nail or end of the director, and expose the internal jugular vein, which being pressed aside (inward), pass the needle around the artery from below upward to avoid the pleura. To tie the *left* subclavian on the tracheal side of the scaleni, place the patient in a position corresponding to that above described. Make an incision three and one-half inches long, through the skin and platysma myoides, on the inner edge of the sterno-cleido-mastoid muscle, terminating at the sternum; this is to be met by another incision along the sternal part of the clavicle, two and one-half inches in length. Divide the sternal and half of the clavicular origin of the sterno-cleido-mastoid muscle on a director, and raise the angular flap. Penetrate the deep fascia with the handle of the scalpel and the fingers. Continue the dissection along the outer side of the internal jugular vein to the inner edge of the scalenus anticus muscle, half an inch above the first rib, to avoid the thoracic duct. The phrenic nerve must be recognized and avoided; and the fingers pressed to the bottom of the wound will discover the rib, and then the artery. Pass the needle from below upward. (J. Kearney Rodgers.)

*Operation at the Second Part.*—The portion of the artery embraced between the scaleni muscles is very short. It is covered by the skin, the platysma myoides, the sterno-cleido-mastoid muscle, and the scalenus anticus, upon which rests the phrenic nerve; below, lies the pleura; and above, the brachial plexus of nerves. Lay bare the deep cervical fascia by an incision three and one-half inches in length, parallel to and half an inch above the clavicle, commencing at the inner edge of the trapezius muscle. Penetrate this fascia by tearing it with the handle of the scalpel and with the fingers. Divide the outer part of the clavicular origin of the sterno-cleido-mastoid muscle. Find the tubercle of the first rib, and the insertion into it of the scalenus anticus. Bring into view the phrenic nerve as it passes over this muscle, in order to avoid it. Begin at the outer edge of the muscle, some distance from the rib, and cautiously divide its fibres from before backward, and from without inward; the retraction of the severed fibres will expose the artery. The portion of the muscle upon which rests the phrenic nerve must not be disturbed. If the muscle be incised too near the rib, the internal mammary artery may be wounded. Pass the needle from without inward.

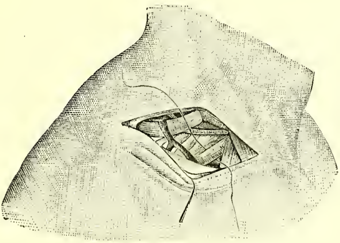
*Operation at the Third Part, or the Point of Election.*—To tie the subclavian artery external to the scaleni muscles, place the patient on his back with the shoulders moderately raised, the head extended, the face turned somewhat to the opposite side, and the arm drawn downward. Make an incision through the skin, two and one-half or three inches in length, about half an inch above and parallel to the clavicle, from the anterior border of the trapezius to the posterior border of the sterno-cleido-mastoid muscle. Divide the platysma, with the superficial fascia, and the border of the sterno-cleido-mastoid muscle will be exposed; the external jugular vein must not be injured. With the fingers and the handle of the scalpel divide the connective and adipose tissue. The omo-hyoid muscle and supra-scapular artery are to be drawn upward. Continue the dissection, by means of the fingers and the handle of the scalpel only, through the adipose and connective tissue with its veins, to the scalenus

anticus muscle, the outer edge of which can be distinctly felt extending upward from the tubercle of the first rib; behind and just external to the outer edge of this muscle, the pulsations of the artery can be felt. The inner border of the brachial plexus of nerves now appears, and is to be drawn upward and outward. Between the scalenus anticus and the brachial plexus, but somewhat deeper than the latter, lies the artery. Divide the deep layer of the cervical fascia with the fingers and the handle of the scalpel, or the point of the director, and the artery then comes into view. The subclavian vein lies in front of and below the tendon of the scalenus anticus, and close to the clavicle. Open the sheath of the artery by tearing it with the finger nail, and gently insinuate the point of the needle, from before backward and slightly from within outward, keeping it close to the artery. Also guide the point of the needle by the end of the finger, and prevent it, when emerging on the opposite side, from including a branch of the brachial plexus. Injury of the external jugular vein (at the outer border of the sterno-cleido-mastoid), of the supra-scapular artery (above the clavicle), and of the phrenic nerve (running downward upon the scalenus anticus), must be avoided.

Sometimes the clavicular portion of the sterno-cleido-mastoid muscle has an unusually broad attachment to the clavicle, as has also the trapezius, in which case the clavicular attachment of the former must likewise be divided until sufficient room is obtained. Sometimes, too, the external jugular vein enters the supra-clavicular fossa at such a point that it cannot be drawn into either angle of the incision, in which case it must be tied with two ligatures and divided between them.

The cutaneous incision directed above is substantially that recommended by Hodgson (Fig. 479). Roux, however, advised a longitudinal incision, the

Fig. 479.



Hodgson's operation for tying the subclavian artery external to the scalenus anticus. (Sédillot.)

lower end of which should rest on the clavicle; Marjolin advocated an incision shaped like an inverted ⊥; and Physick preferred one fashioned like the letter V. But, as Sédillot justly observes, the procedure of Hodgson is the simplest and the best, and ought to be generally adopted. It has been sanctioned by Lisfranc, Sanson, Velpeau, Sédillot, etc., in France, and, I believe, is generally preferred by the surgeons of Great Britain and America. I also know from experience that the artery can be exposed with great facility by this method.

But the ease and celerity with which the operation is performed will very much depend upon keeping the surface of the dissection unstained with blood, which can be done, as I likewise know from experience, by not using the cutting edge of the knife at all, in ordinary cases, after dividing the

platysma myoides, the dissection being prosecuted with the fingers, etc., in the manner above described, and the landmarks of the operation being constantly kept in view or felt for: these are the omo-hyoid muscle and the brachial plexus of nerves, above; the first rib, below; the tense, sharp, outer edge of the scalenus anticus, together with the tubercle of the first rib, internally; and the pulsations of the artery itself just behind and external to the outer edge of the scalenus anticus muscle.

The operation of ligating the subclavian artery on the *outer side of the scaleni muscles* was attempted, for the first time, in 1809, by Sir Astley Cooper. In the same year a ligature was passed around the artery for axillary aneurism, by Ramsden, at St. Bartholomew's Hospital, and the patient survived five days. Between that date and 1816, the operation was repeated by Sir William Blizard, by Thomas Blizard, and by Dr. Colles, but all three of the patients died. The first successful deligation of the subclavian artery was performed, in 1817, by Dr. Wright Post, of New York; and in 1820, Liston obtained an equally happy result from the same operation.

The operation of tying the subclavian on the *tracheal side of the scaleni* was performed, for the first time, in 1818, by Dr. Colles, and with a fatal result. It appears to have been practised nineteen times, death following in every instance. Five of these operations have been performed in America: by J. Kearney Rodgers, in 1845; by Valentine Mott, in 1851; by Willard Parker, in 1863; and by S. C. Ayres and C. H. Bullen, in 1864. The two last mentioned cases occurred during the late civil war.

The operation of ligating the subclavian artery *between the scaleni muscles*, that is, in the second part of its course, was likewise twice performed during the late civil war, namely, by Surg. J. H. Grove, U. S. Vols., at Rome, Ga., in 1864; and by Surg. B. B. Breed, U. S. Vols., at Nashville, Tenn., in 1865. Both operations were unsuccessful.[1]

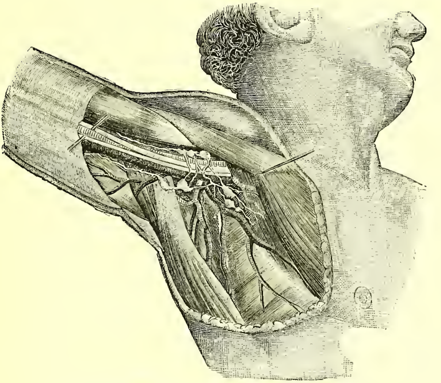
LIGATION OF THE AXILLARY ARTERY.—*Surgical Anatomy.*—The axillary artery gently curves outward and somewhat downward, through the middle of the axillary space, from the inferior margin of the first rib to the inferior border of the latissimus dorsi muscle, where it becomes the brachial artery. (Figs. 478, 480.) It is crossed by the pectoralis minor muscle, which divides its course into three unequal parts, namely: (1) the part internal to or above the pectoralis minor; (2) the part behind or covered by that muscle; and (3) the part external to or below it (Fig. 478).

*Relations.*—Having emerged underneath the costo-coracoid membrane, the artery is in immediate relation with the axillary vein, which lies at first to the inner side, and then in front of it. Near the middle of the axilla, the artery is embraced by the two heads of the median nerve, and is crossed in front by the pectoralis minor muscle. Internally, that is, on the thoracic side, it is in relation above with the first intercostal muscle; it next rests upon the first serration of the serratus magnus; and below, it is separated from the chest by the brachial plexus of nerves. Externally, that is, on the humeral side, it is separated at first from the brachial plexus by a triangular cellular interval; it next rests against the tendon of the subscapularis muscle; and, finally, is in contact with the coraco-brachialis muscle. Seven important branches issue from it.

*Hogdson's Operation.* (Fig. 481.)—The patient having been placed on his back, the operator makes a semilunar incision through the integuments, just below the clavicle, three or four inches in length, commencing about

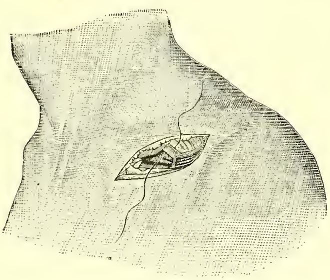
[1] Medical and Surgical History, etc., First Surgical Volume, pp. 546, 547.

Fig. 480.



Surgical anatomy of the axillary region (Sédillot.)

Fig. 481.



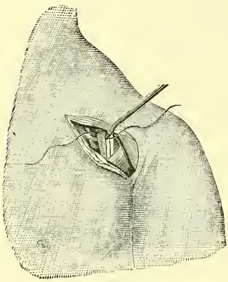
Hodgson's operation for tying the axillary artery immediately under the clavicle. (Sédillot.)

an inch from the sternal end of the clavicle, and terminating near the anterior margin of the deltoid muscle's attachment to that bone, taking care not to cut the cephalic vein. The fibres of the pectoralis major are to be divided in the same direction and to the same extent. The semilunar flap thus formed is then raised, when the pectoralis minor will be seen crossing the inferior part of the wound. The pulsations of the artery can be distinctly felt between the superior margin of this muscle and the clavicle. The axillary vein lies below the artery, but if swollen it may overlap it. One trunk of the brachial plexus of nerves lies above, and in contact with the artery, but the other trunks thereof run behind it. The artery is isolated by scratching with the finger nail, and passing the needle under it from before backward, and slightly from within outward, avoiding the vein. The point of the needle is guided with the point of the index finger, as it emerges, and is thus kept from taking up any branch of the brachial plexus of nerves.

*Chamberlaine's Operation.*—Make a transverse incision, three inches in length, through the skin and platysma, along and upon the lower edge of the clavicle, commencing three fingers' breadth from the sternal end of that bone, and ending about an inch from the acromion process of the scapula. Make a second incision, three inches in length, obliquely through the integuments, over the deltoid and pectoral muscles, meeting the first nearly in the centre. Remove the cellular membrane and fat. Detach the clavicular portion of the

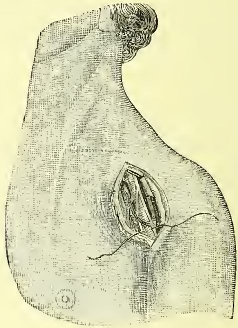
pectoralis major, and remove the cellular tissue overlying the axillary vessels. The artery is now brought into view, and its pulsations make it clearly distinguishable from the contiguous parts. The pectoralis minor and the margin of the deltoid are also brought into view (Fig. 482). Separate the artery from the axillary vein lying in front, and from the brachial plexus of nerves behind. Cautiously pass a ligature with the improved American or with Mott's artery needle, keeping the point of the instrument close to the artery so as not to embrace any other part. The cephalic vein must not be injured by the incisions.

Fig. 482.



Chamberlaine's operation for tying the axillary artery. (Sédillot.)

Fig. 483.



Delpech's operation for tying the axillary artery. (Sédillot.)

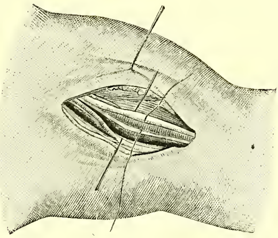
*Delpech's Operation.*—Make a slightly oblique incision downward from the junction of the outer third with the inner third of the clavicle, along the interstice between the pectoralis major and deltoid muscles (Fig. 483). Strongly separate or retract these muscles, and divide the pectoralis minor on a grooved director. Then introduce the left index finger to the bottom of the wound, and, bending it like a hook under the mass of vessels and nerves, draw them outward. Tie the artery at the point where it is embraced between the two heads of the median nerve, carefully avoiding the axillary vein, which lies below and internally, and the trunks of the brachial plexus of nerves, which are found above and external to it.

This procedure has the serious fault of requiring the nerves and vessels to be pulled or dragged with more or less of violence, and to be isolated by lacerating the cellular tissue which surrounds them. The operations of Hodgson and Chamberlaine are therefore to be preferred. In performing each of these three operations, especially the last, care must be taken that the cephalic vein be not wounded.

*Operation in the Axillary Hollow or Armpit.*—Below the pectoralis minor, that is, in the third part of its course, the artery is quite superficial, being covered only by the integuments and deep fascia. Place the patient on his back, with the arm extended and rotated outward (Fig. 484). The operator should stand on the outer side, if it be the right arm, and on the inner side if it be the left arm. Having found the inner border of the coraco-brachialis muscle, and the place where the artery pulsates, make an incision two or three inches

in length, along the line indicated in the accompanying wood-cut (Fig. 484), dividing the skin only. Incise the fascia on a director. Then the axillary vein is to be pushed backward with the end of the director, and next the brachial plexus of nerves. The median nerve is now recognized, and, being drawn forward, while the internal cutaneous and ulnar nerves are pushed backward, the artery is exposed. Cautiously separate the artery from the vein, which is pushed backward, and the nerves that surround it. Pass the needle from behind forward.

Fig. 484.



Ligation of the axillary artery, in the armpit. (Sédillot.)

The axillary artery was ligatured, for the first time, on January 17, 1815, by Mr. R. Chamberlaine, of Kingston, Jamaica, for an aneurism of the left axilla, occasioned by a wound with a cutlass, received October 5, 1814. The operation proved successful.

Ligation of the Brachial Artery.—The brachial artery passes down the inner side of the arm, from the lower border of the latissimus dorsi to a point about an inch below the bend at the elbow, where it divides into the radial and ulnar arteries. Its course is indicated by a line drawn from the junction of the anterior and middle thirds of the axilla to the middle of the bend at the elbow.

*Operation in the Upper Third of the Arm.*—Having placed the patient on his back, with the arm extended and rotated outward, make an incision, two inches in length, along the inner border of the coraco-brachialis. The artery is readily exposed. It lies between and behind the median and ulnar nerves, the former to the outer and the latter to the inner side. It has two venæ comites.

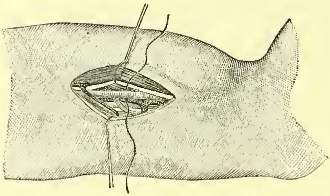
*Operation in the Middle Third.*—The brachial artery in the middle of the arm descends on the inner side, first of the coraco-brachialis, and afterward of the biceps. It is covered by the integuments and fascia, and is slightly overlapped by the biceps. The internal cutaneous nerve lies superficial to the artery. The median nerve obliquely crosses it. The ulnar nerve is internal to it.

The arm being extended at right angles to the trunk, and held supine, the course of the artery may be ascertained by its pulsations; by the internal margin of the biceps and coraco-brachialis; by the median nerve; and by the line above described. The steps of the operation are as follows: (1) The *cutaneous incision* is 4 centimetres (about $1\frac{1}{2}$ inches) in length along the inner border of the biceps. (2) The *biceps* is drawn outward with a retractor. The median nerve is seen lying immediately upon the artery. (3) The *median nerve* is detached from the sheath and drawn outward by a strabismus hook (Fig. 485); the *sheath of the artery* is then opened; it lies between two veins (venæ comites). The arm is now flexed, the artery isolated, and the ligature passed from without inward. Sometimes the brachial artery divides into the ulnar and radial arteries in the upper third of the arm; the radial, in that case, commonly runs more superficially and externally (upon the biceps), while the ulnar appears conspicuously small (Esmarch).

*Operation at the Elbow.*—The brachial artery, at the elbow, lies in the centre of a triangular space, formed externally by the supinator longus, and internally by the pronator radii teres. (1) The *cutaneous incision* is made 4

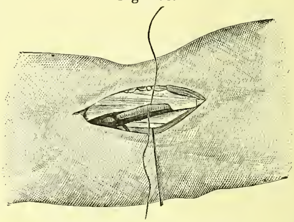
centimetres (about $1\frac{1}{2}$ inches) in length, and 5 millimetres (a fifth of an inch) to the inner side of the tendon of the biceps; carefully, so as not to injure the median vein, which is drawn downward (Fig. 486). The bicipital fascia

Fig. 485.



Ligation of the brachial artery in the middle of the arm. (Sédillot.)

Fig. 486.



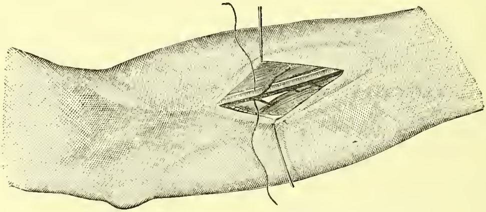
Ligation of the brachial artery at the elbow. (Sédillot.)

is divided. Immediately beneath it is the artery, lying on the brachialis anticus muscle, and between the venæ comites. The median nerve lies a few millimetres inward, and passes beneath the pronator radii teres (Esmarch).

Ligation of the Radial Artery.—Although the radial artery is smaller than the ulnar, it directly continues the course of the brachial artery, and runs in a line drawn from the middle of the bend at the elbow to the inner side of the styloid process of the radius. It is superficial in nearly all its course. The radial nerve lies on its outer or radial side. It has two venæ comites.

*Operation in the Upper Third.*—Having extended the arm in a supine position, and having raised the superficial veins by compressing them above, make an incision through the skin and superficial fascia, two inches in length, along the inner margin of the supinator longus, if this is recognized, or in the line just indicated. Raise the deep fascia on a grooved director, and divide it. Flex the forearm somewhat, to relax the muscles; then, drawing the supinator longus aside, the sheath of the artery is exposed. Pass the needle from without inward (Fig. 487).

Fig. 487.

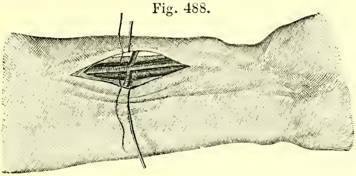


Ligation of the radial artery in its upper third. (Sédillot.)

*Operation in the Lower Third.*—Here the artery lies very superficial, between the tendons of the supinator longus and flexor carpi radialis, and its pulsations are very distinct. The forearm being supine and the hand forcibly extended, to show the flexor tendon, make a light incision, two inches in length, on the radial side of the flexor carpi radialis tendon. Cautiously

raise the deep fascia on a director, and divide it. This brings into view the artery with its venæ comites, and the radial nerve lying on its outer or radial side (Fig. 488). The needle may be passed in either direction.

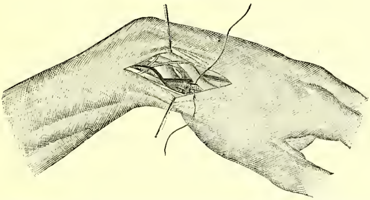
Fig. 488.



Ligation of the radial artery in its lower third. (Sédillot)

*Operation on the Dorsum of the Wrist.*—Below the styloid process of the radius, the artery runs in the groove between the upper extremities of the first metacarpal bones, and a fibrous band separates it from the tendons of the thumb (Fig. 489). It may be ligatured just before it forms the deep

Fig. 489.



Ligation of the radial artery on the dorsum of the wrist. (Sédillot.)

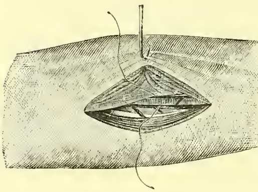
palmar arch; or a little below and behind the extremity of the styloid process of the radius, as it passes under the extensor muscles of the thumb, between the extensor primi internodii and the extensor secundi internodii pollicis. To tie the artery at the commencement of the *deep palmar arch*, make an incision, one inch in length, along the ulnar border of the extensor secundi internodii pollicis, at the angle formed by the first two metacarpal bones, taking care not to wound the superficial veins, and the artery is readily exposed. To tie the artery below and behind the *styloid process of the radius*, place the hand between pronation and supination, the thumb strongly abducted so as to render its extensors prominent. Then make a light incision, one inch in length, between the tendons of the two extensors, commencing at the lower extremity of the radius, and continued in a line with the axis of the first metacarpal bone. Avoid the superficial vein of the thumb. Draw the extensor ossis metacarpi pollicis outward, and the extensor secundi internodii pollicis inward, thus bringing into view the artery and its accompanying veins (Fig. 489).

Ligation of the Ulnar Artery.—The ulnar artery is the larger of the two terminal branches of the brachial. It crosses the forearm obliquely to the commencement of its middle third; it then descends on the ulnar side of the limb to the wrist, crosses over the annular ligament, and forms the superficial palmar arch, which terminates by inosculating with the superficialis

volæ. Its course, in its lower part, is indicated by a line drawn from the inner condyle of the humerus to the external side of the pisiform bone.

*Operation in the Upper Third.*—The forearm should be in a supine position, with the hand strongly extended and inclined to the radial side. (1) The *cutaneous incision* commences 3 centimetres (about $1\frac{1}{4}$ inches) below the fold of the elbow, and runs 4 centimetres (about $1\frac{1}{2}$ inches) along a line, which, in the supine position, separates the ulnar from the central third of the anterior surface of the forearm (Fig. 490). (2) After *dividing the fascia* of the forearm, the interval between the bellies of the flexor carpi ulnaris and flexor sublimis digitorum is to be sought for, and enlarged with the tip of the index finger and a blunt hook. (3) At the bottom lies the *artery*, with its venæ comites; on its ulnar side lies the ulnar nerve (Esmarch). Isolate the artery by flexing the forearm slightly, and the hand strongly. Pass the needle from within outward.

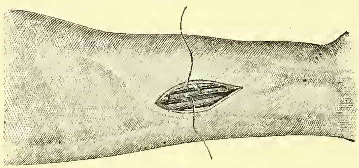
Fig. 490.



Ligation of the ulnar artery at the junction of the upper and middle thirds of the forearm. (Sédillot.)

*Operation in the Lower Third.*—The ulnar artery, in the lower third, is covered by the deep fascia, and has upon its inner or ulnar side the flexor carpi ulnaris and ulnar nerve, and upon its outer side the flexor sublimis digitorum. Place the forearm supine, and extend the hand so as to make prominent the tendon of the flexor carpi ulnaris. (1) The *cutaneous incision* is made 3 centimetres (about $1\frac{1}{2}$ inches) in length, on the radial side of the tendon of the flexor carpi ulnaris, which is inserted into the pisiform bone (Fig. 491).

Fig. 491.

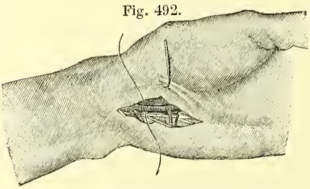


Ligation of the ulnar artery above the wrist. (Sédillot.)

(2) The *superficial layer of the fascia* of the forearm is to be cautiously divided; in like manner the *deep layer*. (3) The *artery*, accompanied by two veins (venæ comites), lies between the tendons of the flexor carpi ulnaris and the innermost tendon of the flexor sublimis digitorum. On its ulnar side lies the ulnar nerve (Esmarch).

*Operation below the Os Pisiforme.*—At the wrist, the artery runs on the radial side of the pisiform bone. The hand being turned backward, make a slightly curved incision about two inches in length and with concavity looking inward, on the radial side of the pisiform bone, through the skin and adipose tissue. The artery is

Fig. 492.

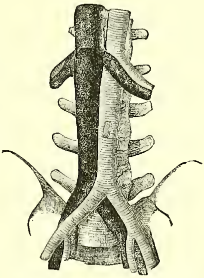


Ligation of the ulnar artery below the pisiform bone. (Sédillot.)

seated deeply in a groove, and the dissection should be continued along the side of the os pisiforme until the vessel is brought into view. The latter part of the dissection will be facilitated by slightly flexing the hand (Fig. 492). Pass the needle under the artery from within outward.

Ligation of the Abdominal Aorta.—The abdominal aorta lies in front, and rather to the left side, of the bodies of the vertebræ, having the vena cava ascendens on its right side, the sympathetic nerve on its left, and the left lumbar veins behind. It may be ligatured about one inch above its bifurcation at the fourth lumbar vertebra.

Fig. 493.



To illustrate Cooper's method of tying the abdominal aorta. (Sédillot.)

*Cooper's Operation* (Fig. 493).—Place the patient on his back, with knees drawn up and legs flexed. Make an incision, three inches in length, along the linea alba, the middle of it being on a level with the umbilicus, but a little to the left thereof, and open the peritoneum. Push the intestines aside, find the artery by its pulsations, and with a finger nail scratch through the peritoneum covering it on the left side. Pass the needle from left to right, taking care not to embrace the sympathetic nerve, and not to injure the vena cava.

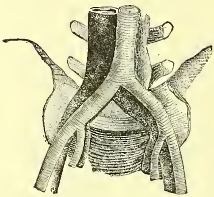
*Murray's Operation.*—Murray made an elliptical incision on the left side, six inches in length, from the cartilage of the tenth rib downward, and with its concavity forward, to within an inch of the anterior superior spinous process of the ilium. The tissues were then carefully divided to the peritoneum, which was raised from the iliac fossa and psoas muscle, when, with great difficulty, and by scratching with the end of a director as well as with the finger nails, room was made to pass the ligature around the artery, which was tied three or four lines above its bifurcation. The patient died in twenty-three hours.

The abdominal aorta was ligatured for the first time in 1817 by Sir Astley Cooper. Next it was ligatured by James, of Exeter, in 1829; by Murray, at the Cape of Good Hope, in 1834; by Monteiro, at Rio Janeiro, in 1842; by South, in 1856; and since that time by Hunter McGuire, of Richmond (1868), by Stokes, by Watson, and by both Czerny of Vienna and Czerny of Heidelberg, making in all ten operations with ten deaths. The most interesting of these cases was Monteiro's, in which the aorta was tied for a large false aneurism on the lower and right side of the abdomen. The incisions were made much as in Murray's case, and the artery was ligatured with great difficulty. The patient died from secondary hemorrhage on the tenth day.

Ligation of the Common Iliac Artery.—*Surgical Anatomy.*—The common iliac arteries begin at the bifurcation of the abdominal aorta on the left side of the body of the fourth lumbar vertebra, a point directly behind the left side of the umbilicus. They vary in length from three-fourths of an inch to three inches, averaging about two inches (L. Holden). They diverge from each other, and run downward and outward on each side to the margin of the pelvis opposite the sacro-iliac synchondrosis, where they in turn each divide into the external and internal iliac arteries. The artery on the right side has on an average the same length as the artery on the left side (L. Holden). But the surgical relations of the two arteries are not identical.

The right common iliac artery is covered in front by the peritoneum, the ileum, and, at its termination, by the ureter. The two common iliac veins pass behind it, and, near its origin, the inferior vena cava and the right common iliac vein lie on its outer side.

Fig. 494.

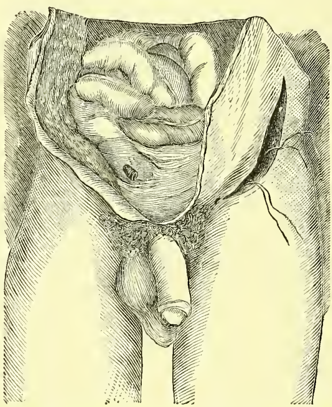


Showing the relation of the common, external, and internal iliac arteries to their accompanying veins. (Sédillot.)

The left common iliac artery is covered anteriorly by the peritoneum, the rectum, and the superior hemorrhoidal artery, and, at its termination, by the ureter. The left common iliac vein is on the inner side and also behind the artery (Fig. 494).

*Operation.*—Place the patient on his back, but inclining to the opposite side. The course of the vessel can be ascertained by drawing a line from the umbilicus to the middle of Poupart's ligament. Make an incision through the integuments and superficial fascia, commencing just anterior to the end of the eleventh rib, downward, one inch and a half within the anterior superior spinous process of the ilium, and terminating just above the internal abdominal ring by a sharp curve upward and inward (Fig. 495).

Fig. 495.



Showing an operation performed by Surgeon J. Cooper McKee, U. S. Army, for tying the left internal and common iliac arteries. From a photograph of the cadaver. The wound of operation was seven inches in length. For an account of the case, see Medical and Surgical History, etc. Second Surgical Volume, p. 334.

The entire length of the incision is about seven inches. Next divide the three abdominal muscles, and cautiously separate the fascia transversalis from the peritoneum, beginning at the upper part of the wound where the adhesion is slightest. Now gently raise the peritoneum from the iliac fossa, and press it inward toward the pelvis. Find the external iliac artery by its pulsations, and carry the finger along that vessel, still detaching the peritoneum, until the common trunk is reached. Then the ureter, in front, is carefully pushed aside, and the needle is passed from within outward.

There is great danger of tearing the peritoneum while effecting the detach-

ment of it from the fascia transversalis; and, in order to avoid this accident, the work of separating the fascia transversalis from it should be begun high up in the wound of operation, where the attachments are the weakest. Again, there is great danger of rupturing the peritoneum while separating it from the iliac fossa; and, in order to avoid this accident, the peritoneum, with the intestines inclosed therein, should be cautiously raised up on the palms of an assistant standing on the other side of the patient, while the operator, with his fingers, gently severs the attachments.

The common iliac artery was ligatured for the first time in 1812, by Professor William Gibson, of Philadelphia, for hemorrhage from a gunshot wound; but the patient died, thirteen days after the operation, from a renewal of the bleeding. This artery was ligatured for aneurism for the first time in 1827, by Dr. Valentine Mott, of New York; the patient recovered. The statistics which have been collected show that the common iliac artery has been ligatured about sixty-eight times, with only sixteen recoveries.

LIGATION OF THE INTERNAL ILIAC ARTERY.—*Surgical Anatomy.*—The internal iliac artery issues from the common iliac at the sacro-iliac synchondrosis. It runs downward and forward to the upper margin of the great sacro-sciatic foramen. It usually is about one inch and a half in length. It is in relation, anteriorly, with the ureter, which separates it from the peritoneum; posteriorly, with the internal iliac vein and the lumbo-sacral nerve; it rests on the sacral plexus of nerves and the pyriformis muscle; on the left side it is overlapped by the rectum.

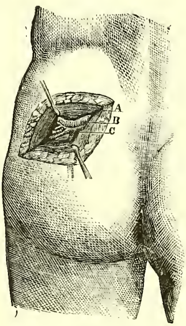
*Operation.*—The steps of the procedure required to expose the internal iliac artery are identical with those employed to expose the common iliac artery (Fig. 475). The needle should be passed from within outward, keeping its point close to the artery, to avoid injuring the internal iliac vein, which lies behind and to the inner side of it. The internal iliac artery may also be ligatured by making an incision five inches in length, half an inch outside of, and parallel to, the epigastric artery, as was practised by Stevens. Finally, it may be ligatured by making an elliptical incision seven inches in length, commencing two inches to the right or left of the umbilicus, according to the case, and ending near the external abdominal ring, with its convexity toward the ilium (White).

The internal iliac artery was ligatured for the first time in 1812, by Stevens, of Santa Cruz; the operation proved successful. Since his time, the operation has been frequently repeated, the whole number of cases being about twenty-seven, with eight recoveries.

LIGATION OF THE GLUTEAL ARTERY.—*Surgical Anatomy.*—The gluteal artery emerges from the pelvis, through the upper margin of the great sacro-ischiatic foramen, and at the upper border of the pyriformis muscle. It is covered by the gluteus maximus muscle. It is accompanied by two veins, and by the gluteal nerve.

*Operation.*—A line drawn from the posterior superior spinous process of the ilium to the apex of the trochanter major indicates the course of the artery. Place the patient on his belly, with his thigh extended. Make an incision four or five inches in length, on the line just mentioned, through

Fig. 496.



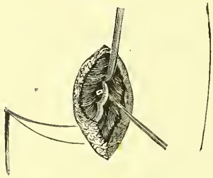

Ligation of the left gluteal artery. (Follin.) A. Gluteus maximus. B. Gluteal artery. C. Gluteal veins.

the skin and subcutaneous adipose tissue (Fig. 496). It will run parallel with the fibres of the gluteus maximus muscle, which should be separated, and a finger introduced, in order to find the artery by its pulsations. Then separate the pyriformis and gluteus medius muscles, between which it lies, and the borders of which cover it. Isolate the artery from its venæ comites, and pass the ligature around it, taking care not to include the gluteal nerve.

The gluteal artery was tied in 1808 by Bell, and in 1833 by R. Carmichael; since that time the procedure has been repeated by several others, and may now be considered an established operation.

Ligation of the Ischiatic Artery (Fig. 497).—*Surgical Anatomy.*—The ischiatic artery escapes from the pelvis through the great sacro-ischiatic foramen, between the pyriformis and coccygeus muscles, and descends in the interval between the trochanter major and the tuberosity of the ischium. It is separated from the gluteal artery by the pyriformis muscle, and is covered by the gluteus maximus. It is accompanied by the ischiatic nerves, and by a vein which lies at its posterior and inner side.

Fig. 497.

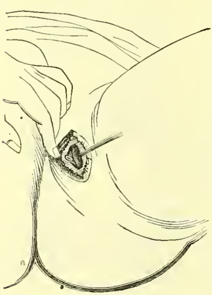


Ligation of the ischiatic artery.

*Operation.*—The centre of a line drawn from the posterior superior spinous process of the ilium to the tuberosity of the ischium, indicates the point where the artery passes out from the pelvic cavity. Place the patient upon his belly. Make a longitudinal incision two inches long, the centre of which corresponds to the point of emergence of the artery, as just described. Divide successively the skin, the cellulo-adipose tissue, and the fibres of the gluteus maximus muscle. The artery is to be found on the inner side of the nerves, and must be carefully separated from the vein. The position of the artery is to be ascertained by inserting a finger into the wound and feeling its pulsations.

Ligation of the Internal Pudic Artery (Fig. 498).—*Surgical Anatomy.*—The internal pudic artery is the smaller of the two terminal branches of the anterior trunk of the internal iliac. It descends in front of the ischiatic artery to the lower border of the great sacro-ischiatic foramen. It emerges from the pelvis through the great sacro-ischiatic foramen, below the pyriformis muscle, crosses the spine of the ischium, and re-enters the pelvis through the lesser sacro-ischiatic foramen; it then crosses the internal obturator muscle to the ramus of the ischium, being situated about an inch from the margin of the tuberosity, and bound down by the obturator fascia; it next ascends the ramus of the ischium, enters between the two layers of the deep perineal fascia, and rises along the ramus of the os pubis. At the symphysis it pierces the anterior layer of the deep perineal fascia; and, very much lessened in size, it reaches the dorsum of the penis, along which it runs to supply that organ, under the name of the *arteria dorsalis penis.*

Fig. 498.



Ligation of the internal pudic artery.

*Operation.*—(1) The artery may be ligatured on its emergence from the great sacro-ischiatic foramen by making the same incisions as those employed for exposing the ischiatic artery; the pudic artery is found a little internal thereto, accompanied by its venæ comites and by the internal pudic nerve.

(2) The artery may be ligatured, in the perineum, as it ascends the ramus of the ischium and os pubis. Draw a line from the middle of the pubes to the inner border of the tuber ischii. Place the patient in the position for lithotomy; make an incision two inches in length along the ramus of the pubis, near the arch; by careful dissection the artery is found running along the inner border of the ramus, where it may be separated from its venæ comites and the internal pudic nerve, and where a ligature may be applied. Care must be taken not to wound the corpus cavernosum.

Ligation of the Arteria Dorsalis Penis.—This artery attains the dorsum of the penis by ascending between the two crura and the symphysis pubis, and runs forward, through the suspensory ligament, in the groove of the corpus cavernosum to the glans, distributing branches in its course to the body of the organ and to the integuments. It is enveloped in the subcutaneous fascia; and is accompanied by the dorsalis penis nerve and vein, which structures must not be injured in exposing and ligaturing the artery.

*Operation.*—Make an incision three-fourths of an inch in length, commencing two inches in front of the pubes, and exactly in the median line, through the skin and the superficial lamina of the subcutaneous layer. Thereby the artery is fully exposed. Pass a small artery needle around it, carefully avoiding the vein and the nerve which accompany it.

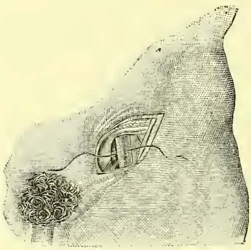
Ligation of the External Iliac Artery.—*Surgical Anatomy.*—The external iliac artery, on each side, runs obliquely downward along the inner border of the psoas muscle, from a point opposite the sacro-iliac synchondrosis to the femoral arch, where it becomes the femoral artery. In front it is in relation with the spermatic vessels, the peritoneum, and a thin layer of fascia, derived from the iliac fascia, which envelops the artery and the accompanying vein. At its commencement it is crossed by the ureter; and, near its termination, by the crural branch of the genito-crural nerve, and the circumflex iliac vein. Posteriorly, it is in relation with the external iliac vein, which gradually passes to its inner side, where it is found at the femoral arch. Externally, it lies against the psoas muscle, from which it is separated by the iliac fascia. Internally, below, passes the vein, as just stated; and, curving along its side, the vas deferens. It is surrounded throughout its entire course by lymphatic vessels and ganglia. Near its termination it sends off two branches, the epigastric and the circumflex iliac arteries. It is about four inches in length, and its course corresponds to a line drawn from the left side of the umbilicus to a point midway between the anterior superior spinous process of the ilium and the symphysis pubis. It may be ligatured in any part of its course, excepting at its upper and lower extremities.

*Abernethy's Operation.*—An incision about three inches in length was made through the integuments, in the direction of the artery, beginning a little above Poupart's ligament, and more than half an inch on the outside of the upper part of the abdominal ring, to avoid the epigastric artery. The aponeurosis of the external oblique muscle being exposed, was next divided in the direction of the external wound. The lower part of the internal oblique muscle was thus uncovered, and the finger being introduced below the inferior margin of it and of the transversalis muscle, they were divided with the crooked bistoury for about one inch and a half. Mr. Abernethy now introduced his finger beneath the bag of the peritoneum, and carried it upward

by the side of the psoas muscle, so as to touch the artery about two inches above Poupart's ligament. He took care to disturb the peritoneum as little as possible, detaching it to no greater extent than was requisite to admit his two fingers to touch the vessel. The pulsations of the artery made it clearly distinguishable. By means of an eyed probe two ligatures were conveyed under the vessel; one of them was carried upward as far as the artery had been detached, and the other downward; they were firmly tied, and the vessel was divided in the interspace between them.[1] Stevens, of Santa Cruz, tied the *internal* iliac by an operation which was substantially the same as that of Abernethy.

*Sir Astley Cooper's Operation.*—A semilunar incision is to be made through the integuments in the direction of the fibres of the aponeurosis of the external oblique muscle (Fig. 499). One extremity of this incision will be situated near the anterior superior spinous process of the ilium; the other will terminate a little above the inner margin of the abdominal ring. The aponeurosis of the external oblique muscle will be exposed, and is to be divided throughout the extent and in the direction of the external wound. The flap which is thus formed being raised, the spermatic cord will be seen passing under the margin of the internal oblique and transverse muscles. The opening in the fascia which lines the transverse muscle, through which the spermatic cord passes, is situated in the mid-space between the anterior superior spinous process of the ilium and the symphysis pubis. The epigastric artery runs precisely along the inner margin of this opening, beneath which the external iliac artery is situated. If, therefore, the finger be passed under the spermatic cord through this opening in the fascia which lines the transverse muscle, it will come into immediate contact with the artery, which here lies on the outside of the external iliac vein. The artery and vein are connected together by dense cellular tissue, which must be separated to enable the operator to pass a ligature, by means of an aneurism-needle, between them and around the artery.[2] Care must be taken to avoid the epigastric artery, which runs near the inner part of the incision. Dupuytren, while performing this operation at the Hôtel-Dieu, in the autumn of 1821, wounded the epigastric artery. The hemorrhage was so copious that two ligatures were required. Death from peritonitis ensued.

Fig. 499.



Sir A. Cooper's operation for tying the external iliac artery. (Sédillot.)

*Appreciation.*—Mr. Norman, of Bath, after trying both modes of operating, found that employed by Sir Astley Cooper a more easy way of finding the artery than the longitudinal incision practised by Mr. Abernethy. Samuel Cooper and M. Roux both came to the same conclusion. Mr. Todd, also, after repeated trials of Mr. Abernethy's and Sir A. Cooper's methods on the cadaver, concluded that the plan recommended by the latter afforded the greater facility of applying the ligature to the artery, because more room was obtained by it, and with less disturbance of the peritoneum. For these reasons Cooper's method of ligaturing the external iliac artery, or some slight modification of his method, has almost universally been preferred by sur-

[1] Surgical Observations, 1804.
[2] Hodgson, Diseases of Arteries, etc., pp. 421, 422. London, 1815.

geons of the past and present generations.[1] One of the best of these modifications is very clearly and tersely described as follows:—

*Esmarch's Operation.*—(1) The *cutaneous incision*, which is 1 centimetre (about $\frac{2}{5}$ of an inch) above and parallel to Poupart's ligament, 8 to 10 centimetres (from $3\frac{1}{4}$ to 4 inches) in length, and slightly convex, begins 3 centimetres (about $1\frac{1}{6}$ inches) to the inner side of the anterior superior iliac spine, and ends opposite the internal inguinal ring (without exposing the ring or the spermatic cord). (2) The subcutaneous tissue, the thin superficial fascia, the strong tendinous aponeurosis of the *external oblique*, and the muscular fibres of the *internal oblique* are divided; then the horizontal muscular fibres of the transversalis in the outer angle of the wound. (3) The thin subjacent *fascia transversalis* must be carefully divided. (In fat subjects there is still a thin layer of fat). (4) The *peritoneum* is carefully pressed toward the umbilicus with the fingers bent like a hook (taking care not to strip up the iliac fascia from the pelvic wall and with it the artery). (5) The *artery* lies in contact with the inner border of the psoas muscle; to its inner side is the vein; to the outer side the anterior crural nerve covered by the iliac fascia; the genital branch of the genito-crural nerve crosses the artery obliquely.[2] Open the *sheath* cautiously and insinuate the needle beneath the artery, from within outward, to avoid the vein.

The external iliac artery was ligatured for the first time, in 1796, by Mr. Abernethy, for inguinal aneurism, a disorder which previously had always been deemed incurable. He lost his first two cases, but saved the third and fourth. The operation was first performed in America by Dr. Dorsey, of Philadelphia. During our civil war this artery was ligatured 16 times with only two successes, but this enormous fatality was due not as much to the hazards attending the operation itself, as to the inutility of tying main arterial trunks for shot-lesions of their branches, instead of securing the injured vessels themselves with both proximal and distal ligatures at the seat of the injury; for nearly two-thirds recover when the external iliac artery is ligatured for other causes, 169 recorded cases having given in all but 61 deaths.

Ligation of the Epigastric Artery.—The epigastric artery arises from the anterior face of the external iliac three or four lines above Poupart's ligament. At first it descends; then, passing forward between the peritoneum and the transversalis fascia, it ascends obliquely in a line drawn from the middle of Poupart's ligament to the umbilicus, to the border of the sheath of the rectus. This sheath it enters near the lower third thereof, passes upward behind the rectus muscle, to which it is distributed; and in the substance of that muscle ends by inosculating, near the ensiform cartilage, with the termination of the internal mammary artery. It lies behind the inguinal canal, to the inner side of the internal abdominal ring, and immediately above the femoral ring. It is crossed near its origin by the vas deferens in the male, and by the round ligament in the female. It is accompanied by two veins, almost to its origin.

*Operation.*—Make an incision through the integuments, two and a half or three inches in length, and halt an inch above and parallel to Poupart's liga-

[1] In one instance, however, where I tied the right external iliac artery for inguinal aneurism in a woman, aged about 30, I uncovered the artery, and brought it fully into view by Liston's modification of Abernethy's method, without any difficulty whatever. The wound healed kindly, although the ligature was rather late in coming away; but, after a time, pulsation unhappily reappeared in the tumor, and a relapse occurred. Stephen Smith, I believe, tied the common iliac in this case afterwards, with a fatal result from secondary hemorrhage. Still, I think Cooper's operation is to be preferred.

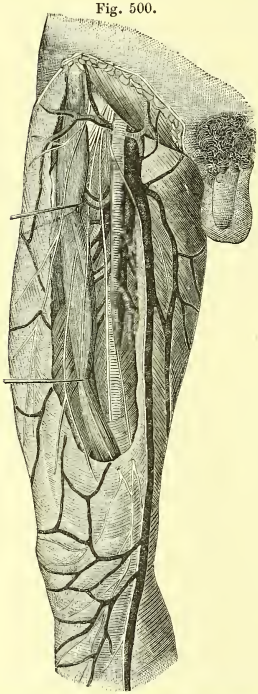
[2] Esmarch's Handbook, p. 155.

ment, to the middle whereof the middle of the wound should exactly correspond; one or two vessels in the superficial fascia will probably require ligation. Next, the tendinous aponeurosis of the external oblique should be raised and divided on a director, and then the lower border of the internal oblique and transversalis muscles raised, when, on tearing through the fascia transversalis, the artery will be exposed near its origin. In passing the needle around the artery, be careful not to include its venæ comites.

The *circumflex iliac artery* may be exposed and tied by the same incisions. After tearing through the transversalis fascia, it will be found running parallel with, and close to, Poupart's ligament.

Ligation of the Femoral Artery.—*Surgical Anatomy.*—The femoral artery descends the inner side of the thigh from the termination of the external iliac behind Poupart's ligament, at a point midway between the anterior superior spinous process of the ilium, and the symphysis pubis, to the opening in the adductor magnus, at the junction of the middle with the inferior third of the thigh, where it becomes the popliteal artery.

Fig. 500.



Showing the surgical anatomy of the femoral region. (Sédillot.)

The femoral artery and vein are inclosed in a strong sheath, the *femoral* or *crural canal*, which is formed to a great extent by aponeurotic and areolar tissue, and by a process of fascia, sent inward from the fascia lata. Near Poupart's ligament, this sheath is much larger than the vessels it contains, and is continuous with the fascia transversalis and the iliac fascia. If the sheath be opened at this point, the artery will be seen to be situated in contact with the outer wall of the sheath. The femoral vein lies next the artery, but separated from it by a fibrous septum. Between the vein and the inner wall of the sheath, but separated from the vein by another thin fibrous sheath, there is a triangular space into which the sac is protruded in femoral hernia. This space is occupied, in the normal state of the parts, by loose connective tissue and by lymphatic vessels, which pierce the inner wall of the sheath, to proceed to a gland situated in the femoral ring.

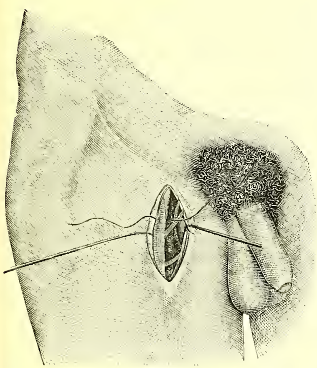
*Relations.*—The upper third of the femoral artery is superficial, being covered only by the skin, the inguinal glands, and the superficial and deep fasciæ. The lower two-thirds is covered by the sartorius muscle. To its outer side, the artery is first in relation with the psoas and iliacus, and then with the vastus internus. Behind, it rests upon the inner border of the psoas muscle; it is next separated from the pectineus by the femoral vein, and profunda vein and artery, and then lies on the adductor longus as far as its termination. Near the lower border of the adductor longus it enters an aponeu-

rotie eanal, formed by an arch of tendinous fibres, thrown from the border of the adductor longus and the border of the opening in the adduetor magnus, across to the side of the vastus internus. To its inner side, it is in relation at its upper part with the femoral vein, and, lower down, with the peetineus, adductor longus, and sartorius.

The immediate relations of the artery are the femoral vein and two saphenous nerves. The vein at Poupart's ligament lies to the inner side of the artery; but, lower 'down, it gets altogether behind, and inelines to its outer side. The short saphenous nerve lies at the outer side, and somewhat upon the sheath for the lower two-thirds of its extent. The long saphenous nerve is situated within the sheath, and in front of the artery to the same extent. The *course* of the femoral artery is indicated by a line drawn from a point midway between the anterior superior spinous proeess of the ilium, downward and inward to the inner side of the internal eondyle of the femur.

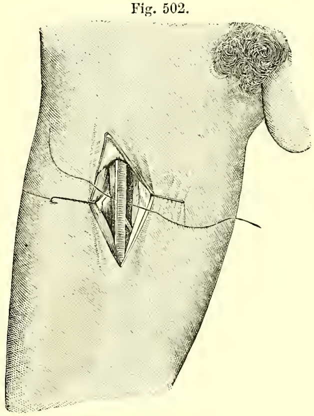
*Operation on the Common Femoral Artery.*—(1) The *cutaneous incision* commences at a point midway between the anterior superior spine of the ilium and the symphysis pubis, two millimetres (one line) above Poupart's ligament, and is carried downward for five eentimetres (about two inches). (2) The *superficial fascia* is divided. (3) The subeutaneous tissue is divided; the lymphatic ganglia are avoided by drawing them aside or by removing them. (4) Division of the *fascia lata.* (5) The *sheath of the vessels* is opened one centimetre (about three-eighths of an ineh) below Poupart's ligament, because immediately below this point the superficial epigastric and superfieial circumflex iliac arteries are given off (Fig. 501). (6) The femoral vein lies on the inner side of the artery, and the anterior crural nerve on the outer side (Esmarch). Pass the needle from within outward.

Fig. 501.



Ligation of the common femoral artery. (Sédillot.)

Fig. 502.



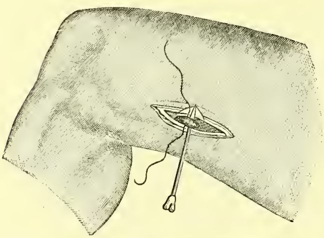
Ligation of the superficial femoral artery at the apex of Scarpa's triangle. (Sédillot.)

*Operation on the Superficial Femoral Artery at the Apex of Scarpa's Triangle* (Fig. 502).—(1) The *cutaneous incision*, five eentimetres (about two inehes) in length, at the inner border of the sartorius, commenees six finger-breadths (eight to ten eentimetres, or from three to four inehes) below Poupart's liga-

ment. (2) The *border of the sartorius* is exposed and drawn outward. (3) The *sheath* is opened. The femoral vein lies to the inner side and somewhat behind the artery; the anterior crural nerve is on the outer side (Esmarch). Pass the needle from within outward, keeping its point close to the artery to avoid the femoral vein. Should the saphenous vein be wounded, it must be ligatured, since the use of pressure to stop the bleeding might interfere with the collateral circulation.

*Operation on the Superficial Femoral at its Lower Third.*—Here the artery enters a fibrous sheath formed by bands which extend from the vastus internus to the adductor magnus and adductor longus, being covered by the sartorius muscle, fasciæ, and integuments. Flex the thigh on the pelvis, and the leg on the thigh, and place the limb on its outer side (Fig. 503). (1) The *cutaneous incision*, 8–10 centimetres (from 3 to 4 inches) in length, is made over the sartorius, in the middle of a line drawn from the anterior superior spinous process of the ilium to the internal condyle of the femur. (2) The *sheath of the sartorius* is opened, the muscle liberated and drawn outward until the posterior wall of the muscular sheath, which covers the canal of Hunter, is exposed. (3) After *opening the canal*, the artery is brought into view; upon it runs the saphenous nerve, and behind it the femoral vein (Esmarch). The vessels are united by very dense connective tissue, and much caution must be used in isolating the artery.

Fig. 503.



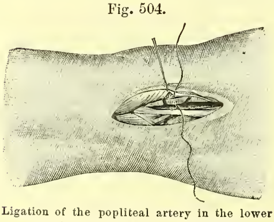
Ligation of the femoral artery in the tendinous canal of the adductor muscles. (Sédillot.)

Ligation of the Popliteal Artery.—The popliteal artery commences at the opening in the adductor magnus muscle, and passes obliquely downward and outward, through the middle of the popliteal space, to the lower border of the popliteus muscle, where it divides into the anterior and posterior tibial arteries (Fig. 504).

*Operations.*—(1) To ligature the artery in the upper part of its course, make an incision three inches in length, beginning at the inferior third of the thigh, and continuing along the external margin of the semi-membranosus muscle. Divide the skin and fasciæ. Separate the connective tissue with the finger and director. Now flex the leg, and first the popliteal nerve appears; next the popliteal vein, to its inner side, and, lastly, the artery itself. Pass the needle from within outward.

(2) To ligature the artery in the lower part of its course (Fig. 504), place the patient on his belly with the leg extended. Make an incision through the skin, three inches long, somewhat to the outer side of the median line. The external saphenous nerve which lies under the skin must be avoided. Cautiously divide the fascia, and then the cellulo-adipose tissue between the heads of the gastrocnemius is to be separated with the finger, so as to expose the popliteal

Fig. 504.

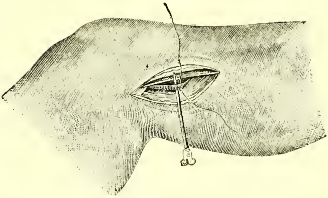


Ligation of the popliteal artery in the lower part of the popliteal space. (Sédillot.)

nerve, the popliteal vein, and the artery. The nerve and vein are to be drawn inward, and the needle passed from within outward.

(3) To ligature the popliteal artery below the internal condyle of the tibia, semiflex the leg, and lay it upon the outer side. The operator, standing on the external side of the limb, should feel for the internal side of the muscular mass which bounds the popliteal space internally and below. He makes an incision, two and a half inches in length, from above downward, from without inward, and from behind forward, along the edge of the internal head of the gastrocnemius muscle, within half an inch of the internal border of the tibia (Fig. 505), taking care to avoid the internal saphenous vein. He then divides the crural aponeurosis a little further back than the skin, and introduces a finger to break down the intermuscular septum, the leg being flexed on the thigh to relax the muscles. Fig. 505 represents the nerve as seen at the bottom of the wound, the artery to the inner side, and the accompanying vein drawn outward.

Fig. 505.



Ligation of the popliteal artery below the inner condyle of the tibia. (Sédillot.)

Ligation of the Posterior Tibial Artery.—The posterior tibial artery passes obliquely downward along the tibial side of the leg, from the bifurcation of the popliteal artery at the lower border of the popliteus muscle to the concavity of the os calcis, where it divides into the internal and external plantar arteries. Its course is indicated by a line drawn from the centre of the popliteal space to a point just behind the inner malleolus.

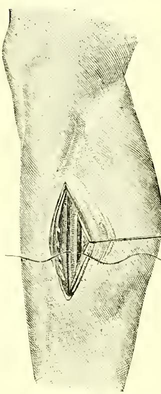
In the *upper third* of the leg, the artery lies very deep, being covered by the tibialis posticus, the deep fascia, the soleus, and the gastrocnemius, as well as by the skin and superficial fascia.

*Operation.*—At a distance of two-thirds of an inch from the inner edge of the tibia, make an incision not less than four inches in length, through the integuments and deep fascia; with the index finger in the wound, detach and push outward the inner head of the gastrocnemius, and likewise separate the attachments of the soleus, thus exposed, from the posterior surface of the tibia; next, whilst an assistant draws this muscle backward and outward with a blunt hook, divide the deep layer of the crural fascia upon a director, and search for the artery immediately underneath; separate the artery from its venæ comites and from the posterior tibial nerve, and be careful not to include either of them while passing the needle around the artery.

In the *middle third* of the leg, the artery lies more superficial, running parallel to the inner edge of the tibia, from which it is separated by the flexor longus digitorum muscle. It is covered by the internal border of the soleus. It is accompanied by two veins, and the posterior tibial nerve here lies on its inner side.

*Operation.*—Three-fourths of an inch behind the inner edge of the tibia, make an incision parallel

Fig. 506.



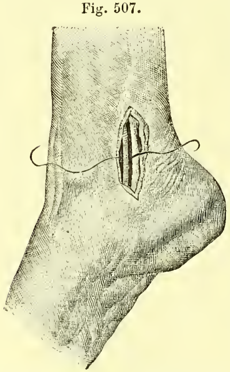
Ligation of the posterior tibial artery at the middle third of the leg. (Sédillot.)

thereto, three inches in length, through the integuments and deep fascia. The border of the gastrocnemius is to be drawn backward, so as to expose the soleus (Fig. 506). Divide the fibres of the soleus on a director; the artery is now felt pulsating about an inch from the edge of the tibia. Next, divide the pearl-colored deep aponeurosis which covers it, and then relax the muscles by changing the position of the leg. Separate the artery from its venæ comites, and press the nerve to the outer side. Pass the needle from without inward, carefully avoiding the veins and the nerve.

In the *lower third* of the leg, the artery descends behind the inner malleolus, running at first parallel to the tendo Achillis, and then midway between the inner malleolus and the tuberosity of the os calcis. It is quite superficial, and in relation anteriorly with the tendons of the tibialis posticus and flexor longus digitorum, and, posteriorly, with the posterior tibial nerve. On each side of it lies one of the venæ comites.

*Operation.*—Having placed the leg on its outer side, and extended the foot, make an incision two inches in length, a finger's breadth behind the inner edge of the tibia, and parallel to it, through the skin and superficial fascia. Raise the deep fascia on a grooved director and divide it. Now, turn aside some adipose tissue, and the artery with its venæ comites and the posterior tibial nerve will be brought into view (Fig. 507). The sheaths of tendons must be carefully avoided. It is to be observed that sometimes the artery lies anterior to the cutaneous incision above directed.

Fig. 507.



Ligation of the posterior tibial artery at the lower third of the leg. (Sédillot.)

At the *inner side of the ankle*, the artery may be ligatured by making a curved incision one inch and a half in length, midway between the inner malleolus and the tendo Achillis. Having divided the skin and superficial fascia, the deep fascia must be raised on a grooved director and freely opened. Immediately underneath should be found the artery, together with the tendons of the tibialis posticus and flexor longus digitorum muscles on the inner side, and the posterior tibial nerve, together with the tendon of the flexor longus pollicis muscle, on the outer side of the vessel. Separate the artery from its venæ comites, etc., and pass the needle around it from without inward, taking care to embrace nothing else.

In the lower third of the leg, there are numerous anastomoses formed by large branches of the internal saphenous vein, which in general run transversely; these may be revealed by compressing the trunk of the vein above them, so that injury to them may as much as possible be avoided.

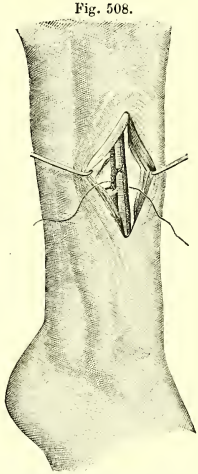
Ligation of the Peroneal Artery.—The peroneal artery arises from the posterior tibial, from one to two inches below the inferior border of the popliteus muscle; it is nearly as large as the anterior tibial artery, and descends obliquely outward to the fibula. It then runs downward along the inner border of the fibula to its lower third, where it divides into the anterior and posterior peroneal artery. As it descends, however, it diminishes in size so rapidly that, below the middle of the leg, it is too small to require a formal deligation.

*Operation.*—Make an incision two and a half inches long over the external border of the fibula, terminating opposite its middle. Divide consecutively the skin, superficial fascia, and deep fascia, whereby the origin of the soleus muscle will be brought into view. This must be detached and drawn inward, when the border of the fibula will be distinctly exposed. The operator now divides the fibres of the flexor longus pollicis, and separates them from the posterior surface of the fibula, at the inner surface of which will be found the artery, at the point where the interosseus membrane joins the bone.

Ligation of the Anterior Tibial Artery.—The anterior tibial artery passes forward between the two heads of the tibialis posticus muscle, and through the opening in the upper part of the interosseous membrane, to the anterior tibial region. It then descends the anterior aspect of the leg to the ankle-joint, where it becomes the arteria dorsalis pedis.

*Relations.*—In its downward course it rests upon the interosseous membrane —to which it is connected by a small tendinous arch that is thrown over it— upon the lower part of the tibia, and upon the anterior ligament of the joint. In the upper third of its course it is situated between the tibialis anticus and extensor longus digitorum; lower down between the tibialis anticus and extensor proprius pollicis; and just before it reaches the ankle-joint, it is crossed by the tendon of the extensor proprius pollicis, and becomes placed between that tendon and the tendons of the extensor longus digitorum. Its immediate relations are with the venæ comites and the anterior tibial nerve, the latter of which lies at first to its outer side, and, about the middle of the leg, becomes placed superficially to the artery. The course of the artery is indicated by a line drawn from the inner border of the fibula, above, to a point midway between the two malleoli, below.

Fig. 508.



Ligation of the anterior tibial artery at the middle third of its course. (Sédillot.)

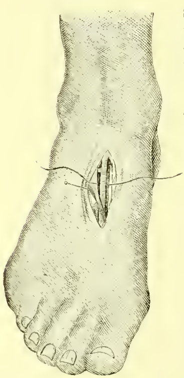
*Operation at the Upper Third.*—Having turned the limb inward, and extended the foot, take as a guide the line just mentioned, or a point ten lines to the outer side of the spine of the tibia, and make an incision four inches in length through the integuments. Divide the deep fascia by a cruciform incision to allow its complete separation. The intermuscular septum is now to be sought for, and may be recognized (*a*) as the first intermuscular space from the tibia; (*b*) on pressure from within outward, by the resistance of the other muscles; (*c*) at the lower part of the incision, by the white line of the muscular interspace being more marked. The foot being flexed, separate the muscles with the index finger; and, the margins of the wound being drawn apart by retractors, expose the artery with its venæ comites and the anterior tibial nerve, the latter of which is outside. Pass the needle from without inward.

*Operation at the Middle Third.*—In this part of its course the artery is covered by the skin, the superficial, and the deep fascia. On the inner side it has the tibialis anticus muscle, and, on the outer, the extensor longus digitorum and the extensor proprius pollicis (Fig. 508). Having placed the limb in the same position as directed above, make an incision three and a half inches in length, along the course of the artery, and through the integu-

ments. The septum in the deep fascia is to be recognized by its white line. Divide it longitudinally, and likewise by a cruciform incision. Flex the foot to relax the muscles, when, the sides of the wound being separated by drawing the tibialis anticus inward, and the extensor longus digitorum and extensor proprius pollicis outward, the anterior tibial nerve is found lying more superficial than the artery and its accompanying veins. Pass the needle from within outward.

*Operation at the Lower Third.*—Here the artery is covered by the integument and the fasciæ, and is crossed by the tendon of the extensor proprius pollicis. Low down, it lies between the tendon of this muscle and the tendons of the extensor longus digitorum. It is accompanied by two veins and the anterior tibial nerve; the latter runs to the outer side. Having placed the leg in a horizontal posture and extended the foot, and having recognized the position of the tibialis anticus muscle, make an incision three inches in length, along the external border of that muscle, on the line already indicated, but not extending to the annular ligament. On a grooved director, carefully incise the deep fascia, and find the space between the tibialis anticus and tendon of the extensor proprius pollicis, and separate them with the index finger. Now flex the foot and expose the artery, which rests on the tibia with the nerve superficial to it. Separate the artery from the venæ comites, and pass the needle from within outward, the nerve being drawn inward. If the incision happen to fall between the tendon of the extensor proprius pollicis and the tendons of the extensor communis digitorum, the ligature may still be passed around the artery.

Fig. 509.



Ligation of the arteria dorsalis pedis. (Sédillot.)

Ligation of the Arteria Dorsalis Pedis.—The dorsalis pedis artery runs forward along the tibial side of the dorsum of the foot, from the ankle-joint to the great toe, where it divides into two branches, the dorsalis hallucis and the communicating. Its course corresponds to a line drawn from the middle of the inter-malleolar space to a point midway between the anterior extremities of the first two metatarsal bones. It is covered by the integument, the fasciæ, and the innermost tendon of the extensor brevis digitorum. On its inner side lies the tendon of the extensor proprius pollicis, and on its outer side the inner tendon of the extensor longus digitorum. It is accompanied by the veins, and externally by the anterior tibial nerve.

*Operation.*—Make an incision two inches in length, on the line above described (Fig. 509), parallel to the external border of the tendon of the extensor proprius pollicis. Divide the deep fascia on a grooved director. Draw the internal division of the extensor brevis digitorum outward, and the artery with its venæ comites will be exposed. The nerve lies on the outer side. Pass the needle from within outward.

# SURGICAL DISEASES OF THE VASCULAR SYSTEM.

BY

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## Phlebitis.

In February, 1784, before the London "Society for the Improvement of Medical and Chirurgical Knowledge," John Hunter read a dissertation in which he described an adhesive, suppurative, and ulcerative inflammation of the lining membrane of veins, which he had observed as a result of amputations and other complicated surgical operations and injuries. Scientific literature, prior to this date, contains many descriptions of conditions which undoubtedly resulted from phlebitis (Aretæus, Paré, and others); but the morbid anatomy of this inflammatory process had never been so nearly understood and described before this observation of the great English surgeon. Following in the footsteps of Hunter, others, including Baillie, Bichat, Hodgson, Cooper, Travers, and Cruveilhier, contributed to the study of this important subject; but it was not until the more perfect construction of the microscope, in later years, rendered the accurate study of normal histology possible, that the true pathology of phlebitis was thoroughly understood.

Definition and Morbid Anatomy.—*Phlebitis* means an inflammation of all the tissues which enter into the formation of the walls of a vein. *Endophlebitis*, *mesophlebitis*, and *periphlebitis* are terms used to designate the inflammatory process involving respectively the internal, middle, and external layers of the venous wall.

The progress of inflammation in the tissues of veins is closely analogous to that of the same process in all other structures, namely: irritation, hyperæmia, tumefaction, infiltration of the extra-vascular spaces with emigrant, embryonic, and pus-cells; the process terminating in cicatrization (often with adhesions), calcareous degeneration, suppuration, or gangrene. The mode of termination will depend upon the severity of the attack, the character of the lesion, and the power of resistance and recuperation existing in the tissues. The inflammatory process involves a tubular structure, the walls of which are composed of an inner layer (*intima*), made up of flat, polygonal cells (the endothelia), a middle layer chiefly made up of elastic tissue, and an outer layer, containing elastic loops, connective tissue, and unstriped muscle. Blood-vessels and nerves traverse the outer and middle tunics, following the bundles of connective tissue.

The cells of the lining membrane are smaller than the arterial endothelia, and are embedded in a fibrillated, intercellular substance (Cornil and Ranvier). The elastic and muscular tissues are less developed than in the arteries (Heitzmann). These are so irregularly arranged that any division into middle and

external coats is, in great part, artificial and imaginary. Moreover, many of the veins contain no muscular tissue, while their connective tissue varies in quantity in different parts of the body. The sinuses of the dura mater, the veins in bones, and those of the retina, have no muscular fibres, while the jugulars, subclavians, and venæ cavæ have a relatively small quantity, or are entirely devoid of this tissue. Again, the arrangement of the muscular tissue differs in different veins. The inferior vena cava and the portal and renal veins have an inner, circular, and an external, longitudinal layer, while the femoral and popliteal veins have the longitudinal fibres more internal. This tissue is still more complicated in the saphenous veins, where the internal layers are arranged longitudinally, with a number of alternating, or transverse and longitudinal, layers placed externally to these.

The elastic layer begins immediately external to the basement substance which supports the endothelial layer, and is here somewhat isolated and well defined; but from the external surface of this central, elastic lamina springs a network of elastic fibres, through the loops and in the meshes of which are woven the muscular and connective-tissue fibres.

The vasa vasorum follow the connective-tissue bundles in their distribution to the tissues of the wall down to the elastic layer. Nerves from the sympathetic system have been demonstrated in the larger veins.

The valves are delicate reduplications of the internal coat, having a well-defined, elastic reticulum, especially on their distal or convex surface (Heitzmann), and muscular fibres at the point of attachment to the venous wall.

The vascular area—the outer and middle layers—is first concerned in the inflammatory process. The endothelial tunic, as a result of these structural changes, is subsequently involved in the process. It then appears cloudy, thickened, and rough, and may become separated in shreds. (Frey.)

In the vascular area, during the earlier stages, the capillaries of the vasa vasorum become swollen, the white corpuscles emigrate into the extra-vascular spaces, and the normal connective-tissue cells are stimulated into rapid proliferation, resulting in a thickening of the wall, due to the presence of these embryonic cells, and the excessive hyperæmia. As in arteritis, the vitality of the endothelial tunic becomes impaired, and it is more or less projected into the cavity of the vein, the endothelia undergoing rapid proliferation. After a few days, granulation-buds push out from this embryonic tissue of the endothelia, and new capillaries are developed in these granulation-masses, anastomosing and becoming a part of the circulation of the vasa vasorum, as well as leading into the coagulum which occupies the calibre of the vein.

At the point of contact of the outer surface of the thickened endothelial layer with the internal surface of the middle (elastic) layer, large sinuses are developed, which receive the blood from the capillaries of the middle tunic. These sinuses are lined with an endothelial layer, which rests upon the contiguous connective tissue. From these large vessels fine capillaries are given off, which permeate the thickened internal layer, and some of which pass into the organizing coagulum.

When a thrombus, caused by the sudden coagulation of the blood in a vein, is examined in its recent state, it is found to be composed of successive laminæ of fibrin and corpuscles, and the more recent of these laminæ are external. When the vein is first occluded by this sudden coagulation of the blood, the pressure from behind is so great that the coagulum is compressed toward its centre, while the current, more and more impeded in its progress, flows between the periphery of the clot and the inner surface of the vessel, adding layer by layer fresh deposits of coagulation upon the thrombus. A microscopical examination of such thrombi reveals a vast number of white

corpuscles in various stages of fatty degeneration, with layers of fibrin intervening.

If it were not that, flowing in contact with the surface of a vein undergoing an inflammatory process, was the blood, the integrity of which is necessary to tissue-life and welfare, the dangers from this condition would be slight; but experiments have shown that not only does this inflammatory process, by reason of its invasion of the intima, produce changes in the blood which lead to stasis, but that there is a dangerous endosmosis, into the blood-current, of septic matter, which, becoming a part of the current, is swept along and lodged in the various organs toward which it is leading (*emboli*), producing infarctions, abscesses, and, almost invariably, irreparable damage. The adhesion of the intima, and the formation of a fibrinous clot—which may completely occlude the vessel (*occlusion thrombus*), or may merely plaster over the endothelial tunic (*peripheral thrombus*)—are efforts, not always successful, to prevent endosmosis of septic matter.

The process of repair in tissues capable of successful resistance, in venous inflammation, is one of organization of the embryonic cells, fibrillation, and contraction, resulting in partial or complete occlusion. In tissues of low and impaired vitality, the progress of the inflammation is rapidly toward suppuration, usually terminating in septic fever and death. Microscopical sections from such specimens of phlebitis show that the leucocytes and embryonic cells have undergone retrogressive changes, and that the tissues are infiltrated with resulting pus corpuscles. Gangrenous spots are not infrequent, often opening into the calibre of the vessel, and allowing the influx of septic products, or the efflux of blood.

Since phlebitis is a frequent cause of thrombosis, and since venous thrombosis is the most frequent form of intra-vascular coagulation, a consideration of the pathogeny and pathology of this process must naturally find a place here. Virchow has endeavored to show that primitive phlebitis is extremely rare, and that when a clot is produced in a vein which is inflamed, the coagulation has more often preceded than followed the inflammation. Cornil and Ranvier, from whom the above account is taken, do not accept this theory.

Fibrin, the immediate factor in coagulation of the blood, does not exist as such in the normal condition of this fluid. Under healthful conditions, the blood would circulate always without any deposit of fibrillated fibrin in the economy. According to Denis, the normal plasma of the blood can be separated into a semisolid substance—*plasmine*, and a liquid—*serine*. Plasmine is further separable into *fibrin* and *metalbumen*, and it is held that the coagulation of the blood is due to the conversion of plasmine into fibrin. This is the theory of Denis. Foster holds that coagulation is the result of the interaction of two bodies, *paraglobulin* and *fibrinogen*, brought about by the agency of a third body, *fibrin-ferment*. A. Schmidt has carried experimentation further, and is led to believe that paraglobulin and fibrin-ferment both originate in the white blood-corpuscles. This theory is exceedingly seductive, and it cannot be denied that actual pathology proves that around and within inflammatory areas where white blood-corpuscles are most abundant, coagulation and fibrillation are more apt to occur, and a study of thrombi which have been gradually formed, reveals alternating layers of white corpuscles and fibrillated fibrine. (Green.)

What may be the principle in the blood which is the factor of coagulation, or what reaction it is which precipitates the fibrin, we cannot in the present condition of science positively assert. The facts, however, "point to the conclusion that when blood is contained in healthy, living bloodvessels, a certain relation or equilibrium exists between the blood and the containing vessels, of such a nature, that, as long as this equilibrium is

maintained, the blood remains fluid, but when this equilibrium is disturbed by events in the blood or bloodvessels (or by the removal of the blood), it undergoes changes which result in coagulation." (Foster.)

So delicate is the sensibility of the blood to mechanical irritation or hindrance in its flow, that the slightest injury or roughening of the endothelial lining membrane may produce a deposit of fibrillated fibrin. A delicate needle, or wire, or thread, thrust into the lumen of a healthy vessel, precipitates coagulation upon the foreign body. The white corpuscles are found clustered in great numbers on the foreign body, and, when the mass is examined with the microscope, the corpuscles seem to serve as starting points for the development of fibrin. (Reichert.)

Causes and Clinical History of Phlebitis.—Phlebitis has been termed traumatic and idiopathic, and the latter term has been applied indiscriminately to all forms of phlebitis not directly due to an appreciable lesion.

*Idiopathic phlebitis* is comparatively a rare affection (Virchow). It may occur without a traumatism, as from exposure to cold, or as a sequel to fevers and varicosities (Hamilton). It may occur as a complication of syphilis (Hutchinson), or as a result of the gouty diathesis (Paget). From whatever cause it may proceed, idiopathic phlebitis usually affects the veins of the lower extremities.

*Traumatic phlebitis* may be caused by a partial or complete solution of continuity of the venous walls, by contiguity of inflamed tissues, or by violent muscular action and pressure.

The inflammation of the uterine sinuses during and after parturition, which Cornil and Ranvier style "la phlébite spontanée," is really a form of traumatic phlebitis, due to the irritation resulting from pressure and muscular action.

Phlebitis has been described as acute and chronic (Gross); adhesive and suppurative (Bryant); gouty and diffuse (Hamilton). These terms but express varying conditions of one pathological process—*inflammation of a vein;* whether this inflammatory process shall result in adhesion or suppuration, shall become diffused, or shall assume a chronic form, will depend solely upon the character and cause of the disease, and upon the physical power of the patient to resist its progress.

I. Idiopathic Phlebitis. (1) *Syphilitic Phlebitis.*—Mr. Hutchinson has called attention to the very few cases of syphilitic phlebitis which have been recorded, and yet he says that most surgeons are familiar with the fact that inflammations around varices, and even about otherwise healthy veins, are not infrequent in syphilitic subjects.[1] Mr. Hutchinson further says, "I think also that I have seen several cases in which the thrombosis and phlebitis were attended by other conditions sufficiently peculiar to justify a belief that they were of specific origin. In some there has been great excess of inflammation, a large hard mass forming in the cellular tissue, and threatening to slough, much as subcutaneous gummata often do. These cases are much benefited by the iodide of potassium, so far as prevention of sloughing is concerned, but the thrombotic plugging remains."[2]

(2) *Gouty Phlebitis.*—Subjects (says Mr. Bryant) who are gouty from hereditary or acquired causes are liable to phlebitis. Paget has described the affection in his "Clinical Lectures," and Mr. Gay has written upon it. In such cases the phlebitis may have no intrinsic characters by which to distinguish it, yet not rarely it has peculiar marks, especially in its symmetry, apparent metastases, and frequent recurrences. Like other forms, it is more common

[1] J. H. C. Simes and J. Wm. White, in Cornil on Syphilis. [2] Ibid.

in the lower than in the upper extremities, yet it may be found anywhere. It affects the superficial rather than the deep veins, and often occurs in patches, affecting on one day, for example, a short piece of the saphenous vein, and the next, another portion of the same vein, some other distant vein, or a corresponding piece of the opposite vein.

The inflamed portions of the vein usually feel hard and are painful to the touch. The soft parts covering the vein become slightly thickened, and often have a dusky, reddish tint. When the deep veins are involved, œdema appears, with the well-recognized results of obstruction—the limb becomes big, clumsy, featureless, heavy, and stiff; its skin is cool, and may be pale, but more often has a slightly livid tint, which may be recognized by comparison with the other limb; and it has mottlings from small cutaneous veins, visibly distended. The limb thus enlarged feels œdematous throughout, but firm and tight-skinned, not yielding easily to pressure, and not pitting very deeply.

The constitutional symptoms associated with this affection vary from some slight febrile condition to those met with in acute gout. Complete recovery may take place in this as in other forms of phlebitis, the veins becoming pervious in some cases and obstructed in others. The risks of embolism are also the same. (Bryant.)

(3) *Acute Idiopathic Phlebitis* (not gouty or syphilitic).—This form of venous inflammation—caused, as has been said, by exposure to cold, due to the presence of a varicosity, or coming in the course of a severe febrile attack—may involve one or more veins. The disease travels along the vessels in the direction of the heart. The veins become swollen, and are hard to the touch, resembling the normal veins when the return circulation is momentarily arrested, though more cord-like in feel and less elastic. Their course can be traced by the dull-red color of the skin immediately over the diseased vessels. Pain is generally constant, and is rendered more acute by pressure. The œdema of the parts on the distal side of the lesion is commensurate with the obstruction to the return circulation caused by the inflammatory process. The febrile movement varies with the violence of the attack, the rapidity of its progress, the intensity of the inflammation, and the capacity of the tissues to resist invasion. In the severe forms, the clinical history is similar to that of traumatic phlebitis, which will be fully described hereafter. Idiopathic phlebitis is not as dangerous to life as the traumatic variety. It may run a short course, and the patient recover promptly, or it may assume a subacute or chronic form, and remain indefinitely.

II. Traumatic Phlebitis.—When a vein is injured, inflammation will result, if the vessel is penetrated to its cavity, or suffers a solution of continuity. I have even known acute, traumatic phlebitis to result from a prolonged forced flexion of the leg on the thigh, leading to thrombosis and occlusion of the popliteal vein. The simplest form of traumatic phlebitis is that resulting from the operation of venesection. No matter what may be the character of the traumatism, the pathological process is the same. The mode of termination of this process will depend upon the extent and severity of the lesion, and upon the recuperative powers of the tissues involved. Traumatic phlebitis extends from the original lesion along the vessels in the direction of the heart. In the deeper veins it is with difficulty recognized in the earlier stages. The course of the inflammation is marked by a dull, coppery-red staining. Pain is invariably present, and upon pressure is acute. In severe cases the tumefaction spreads from the vessels to the surrounding tissues. Œdema of the parts on the distal side of the lesion will occur in a degree commensurate with the interference with the return circulation. The febrile movement is that of septic fever: chills or rigors, flushes of heat ending in cold and exhausting sweats,

sleeplessness, hectic, anxious expression, and often the "pyæmic breath." The rectal temperature is variable and high; the pulse is thready and rapid, reaching in some instances 160. Sudden and dangerous symptoms may arise in the course of the disease, when particles from the venous thrombi are carried toward the heart. These usually lodge in the lungs, giving rise to sudden pulmonary complications, the result of infarction. The liver, in phlebitis of the veins which go into the portal circulation, is frequently the seat of embolic abscess. Hemorrhage from perforation of the venous wall by ulceration or gangrene, is another source of danger in severe cases of phlebitis.

TREATMENT OF PHLEBITIS.—Positive and complete rest is the first great essential in the treatment of phlebitis. Manipulation or movement is dangerous, since interference will not only exaggerate the inflammatory process, but may possibly cause the separation of thrombi and produce infinite harm in remote organs. If the disease should assume the suppurative form, the inflammation being diffuse and the œdema severe, I should practise free incisions parallel to the veins, secure as free drainage as possible, and employ constant irrigation until the more urgent symptoms had disappeared. I consider quinia to be indicated, not only on account of its well-known tonic and antifebrile properties—although not strictly antiseptic in its action, the bacteria of septic fluids resisting its action to a great extent (Bartholow)—but because it exercises an inhibitory influence upon the emigrant corpuscles (Binz), important factors, as Cohnheim has shown, in the inflammatory process. The use of iron, careful feeding, and a supply of pure air and plenty of it, will complete the constitutional treatment. Locally, the part should be invested with cotton batting, laid upon and not bound to the member affected. The extremity involved should be slightly elevated to favor the return circulation.

## ARTERITIS.

*Arteritis* is a term applied to an inflammatory process which involves the entire thickness of the arterial wall. When the inflammatory change is confined to the inner coat, or intima, it is designated as *endarteritis;* when to the outer coat, or adventitia, as *periarteritis;* and when to the middle coat, or media, as *mesarteritis.*

While arteritis is not an infrequent disease, it is seldom that either of the above subdivisions of this morbid condition exists alone. Endarteritis, if it does not rapidly disappear soon after its inception, will lead in great probability to lesions of the media and adventitia, and in like manner a lesion of the external tunic will in all probability involve, by the extension of the morbid process, the other coats.

There are, however, certain well-defined, circumscribed lesions of the separate tunics. Endarteritis is, as an isolated lesion, capable of demonstration. We shall see that a superficial inflammation of the endothelia, with its resultant fatty degeneration, is not infrequent. Again, mesarteritis exists as a primary and separate inflammation, for primary calcification (denied by some pathologists), which is strictly a disease of the tunica media, precipitates an inflammation in this middle tunic. And since atheroma and other arterial lesions are due to interference with the blood-supply through the vasa vasorum, or to defect in the quality of the blood distributed to the adventitia through which the vessels ramify, we must recognize a periarteritis as the initial stage of this lesion.

Inflammation may be established in any or all parts of the arterial system. One form of arteritis will involve the larger trunks, while another will pass these without molestation, and establish itself in the distant arterioles. Simple endarteritis is most apt to occur in the aorta and arteries of the second magnitude, while syphilitic arteritis, the most marked lesion of which is an endarteritis, rarely attacks the larger trunks, but does its dangerous work in the more or less complete occlusion of the small and smallest arteries.

Inflammation of the bloodvessels, and of the arteries especially, is a process which demands a consideration second in importance to none in the domain of surgery. So protean are the changes it produces, so great the dangers it entails upon tissue life, and so important its early recognition and prompt arrest (if such be possible), that I take the liberty of going beyond the province usually allotted to surgical discussion, and of giving here in condensed form the latest contributions to our knowledge of the histology of the arteries:—

The internal coat of the larger arteries is composed of two parts: (1) An endothelial lining membrane, consisting of a single layer of flat, polygonal, nucleated cells, slightly elongated in the axis of the vessel; in edge view, these cells appear spindle-shaped, on account of the elevation of the nucleus at its centre (Heitzmann); (2) A subendothelial layer of flattened, nucleated, anastomosing cells resting in a fibrillated basement substance, the direction of the fibrillæ being generally parallel with the long axis of the artery (Cornil and Ranvier). In the smaller arteries this layer is exceedingly fine, while in the aorta it is comparatively thick, being composed of two distinct layers. Here the internal of these two layers is longitudinal, the external transverse in direction. The middle coat in the larger arteries, such as the aorta and carotids, is composed of elastic laminæ and of fibres, forming by their anastomoses a continuous system, and holding in the meshes of their loops the muscular tissue, transverse in its direction, and a relatively small amount of connective tissue (Cornil and Ranvier). According to C. Toldt, the muscle-fibres of the middle coat are wanting in the initial portion of the aorta, in the pulmonary artery, and in the arterioles of the retina. In the descending aorta, the common iliac, and the popliteal, small bundles in an oblique or longitudinal direction are interspersed between the circular ones, and in other arteries, such as the renal and spermatic, at the inner boundary of the muscular coat, scanty longitudinal bundles occur, which by some are considered to belong to the inner coat. At times, in the corresponding arteries of different persons, differences are observed in the distribution of the muscles of the middle coat (Heitzmann). On the side nearest the inner coat, the middle tunic is limited by a denser and more defined elastic lamina, which shows, however, on transverse section, a festooned appearance—very important in the study of the pathology of arteritis—and is named the internal layer of the elastic coat. Upon the side of the tunica media nearest the external coat, the elastic fibres pass outward, interlacing freely with the connective tissue of the adventitia. In the femoral, brachial, and other arteries of middle size, the middle coat possesses only one layer, namely, the internal elastic. The muscular fibres are transverse in direction, and form themselves into flattened bundles, separated by connective-tissue bundles and by elastic fibrillæ, which are continuous on the one hand with the inner, elastic layer, and on the other with the elastic network interwoven with the adventitia. There are no vessels in the middle and internal coats. In the external coat are found arteries, capillaries, veins, lymphatics, and nerves.

The small arteries have a middle coat, formed of involuntary muscle-cells, so interwoven that they form a continuous membrane (Cornil and Ranvier).

C. Heitzmann[1] describes this layer as seemingly twined round the artery. The adventitia here is composed of small bundles of connective tissue arranged in the main in a longitudinal direction.

PATHOGENY OF ARTERITIS.—The causes of arteritis are numerous. The most frequently recognized form is that resulting from injury, and known as *traumatic arteritis.* The pathogeny of the *non-traumatic* (*idiopathic*) *arteritis* embraces every form of dyscrasia. It follows in the train of syphilis, rheumatism, gout, alcoholism, and nephritis, with great regularity, and may occur as a result of any morbid process which poisons the blood or impairs its nutritive qualities. These varieties will be considered under special headings.

The sequelæ of arteritis, as far as the arteries are concerned, may be fatty infiltration and degeneration, atheroma, secondary calcification, occlusion, dilatation, aneurism, suppuration, ulceration, and rupture. Remotely, partial or complete loss of function of the organs beyond the lesion, and partial or general necrosis or necrobiosis. I shall consider arteritis under two great heads, *traumatic* and *non-traumatic*, subdividing these as their pathogeny or pathology may justify in the consideration of each separate type.

I. TRAUMATIC ARTERITIS.—Arteritis may result from violence, either from without or from within. External violence will produce an inflammation of all the tunics of an artery, in the majority of cases, while violence from within is more apt to cause an endarteritis. *Arteritis from external causes* is never an uncomplicated injury. The perivascular tissue is of necessity involved in the inflammatory process. In the arteritis resulting from deligation of an artery, from the forcible compression of a vessel, as in bending the knee, from the pressure of a tumor, or from a blow in the track of the artery, there is always an accompanying inflammation of the surrounding, injured tissues.

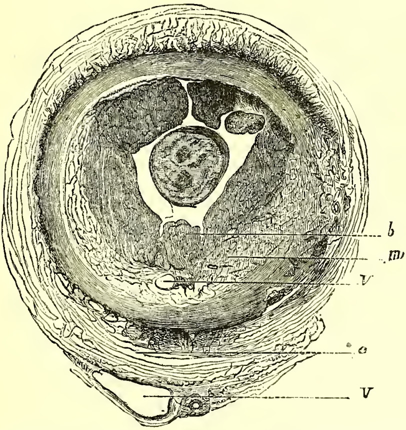
The pathology of traumatic arteritis does not differ greatly from the inflammatory process which occurs in other vascular tissues. Immediately following the injury there is a marked increase in the vascularity of the adventitia. The vasa vasorum become swollen, the white blood-corpuscles crowd into the terminal capillaries, and migrate into the extra-vascular spaces, while a rapid proliferation of the normal cell-elements of the arterial tunics takes place. The connective-tissue cells of the adventitia, the white corpuscles, and the flat and polar cells of the intima, all take part in the morbid process. The walls of the vessel become abnormally thickened, while, owing to the projection inwards of the intima, the calibre of the vessel is diminished. If the intima have been broken or bruised by the injury, the encroachment upon the calibre of the vessel will be more rapid, for in addition to the mass of embryonic tissue pushing into the lumen of the artery, there will be a deposit of fibrin upon the roughened and projecting internal tunic. The white corpuscles in the passing blood-current adhere to the inflamed surface, and undergo a change which causes a liberation of the fibrino-plastic matter which they contain, and a deposit of fibrillated fibrin. This coagulum is found to consist of alternate layers of leucocytes and fibrin. In the mean time, if the inflammation be not so severe that rapid necrosis occurs from the sudden arrest of the blood supply through the vasa vasorum, new-formed capillaries push through the mass of new-formed embryonic cells, into the true "granulation buds" (Fig. 510) which project into the lumen of the vessel.

This form of arteritis may result in permanent occlusion of the vessel (*endarteritis obliterans*), or the function of the artery may be restored. If occlusion occurs, it results from the organization of the embryonic cells into

[1] Microscopical Morphology of the Animal Body in Health and in Disease. New York, 1883.

a new tissue which undergoes fibrillation and contraction, a process of cicatrization, to such an extent that the new-formed capillaries are more or less

Fig. 510.

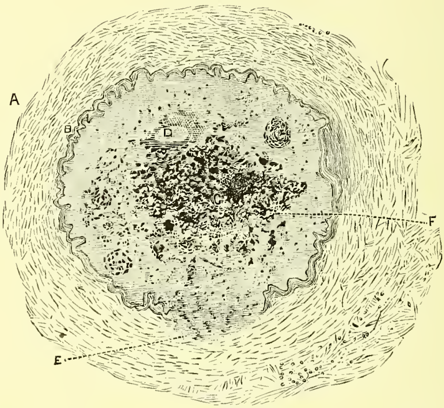



Traumatic arteritis. Transverse section of the carotid artery of a dog, fifteen days after ligature; *b*, granulation buds formed from projection of the intima. In the centre of the figure one of these buds has been completely cut across; *m*, portion of the media modified by the inflammatory process; *e*, adventitia; *V V*, vessels cut across, one of which is newly formed in the intima. Magnified 15 diameters. (After Cornil and Ranvier.)

occluded, and the artery shrinks to become a fibrous cord. (Fig. 511.) Or the coagulum may undergo fatty degeneration and be swept away with the current of blood, the vessel remaining pervious and bearing but little trace of the inflammatory process through which it has passed. The microscopical appearances of a localized traumatic arteritis are typically represented in Fig. 512, which is copied from a section made from the carotid of a horse. The animal was in a healthy condition at the time of the operation. I tied the artery with a broad carbolized ligature, the sciatic nerve of a calf. It was tightly drawn and tied in a double knot. The wound was washed out with five per-cent. carbolic-acid solution, and sewed up. It did not unite by first intention. In the fifth week the animal was killed. The artery was pervious. The location of the ligature was easily recognized by the peculiar, whitish, pearly appearance of the intima at the point of tying, where it was slightly elevated. The adventitia did not show any changes to the naked eye. The ligature had evidently slipped soon after the operation, probably within a few hours. The intima was not broken, but simply bruised within the grasp of the ligature. Active proliferation of the cells of the intima had resulted from this irritation. Not only is the intima seen to bulge into the lumen of the vessel, but the mass of embryonic tissue encroaches outwards upon the media, which is thinner at this point than elsewhere. At one point the media has entirely disappeared, leaving the intima and externa in actual contact. The adventitia has not undergone much change. A few inflammatory corpuscles are found among the connective-tissue bundles. If, after an injury which induces arteritis, the vessel be not occluded throughout the

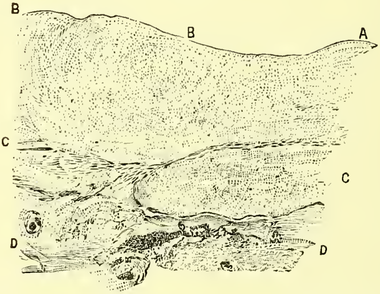
extent of the lesion, and the injury or resulting inflammation be so severe and intense that rapid occlusion of the capillaries in the arterial wall takes place, suppuration and ulceration of the wall occur, with hemorrhage. Or

Fig. 511.




Endarteritis obliterans, not syphilitic. Transverse section of the basilar; A, muscular layer; B, elastic layer. The lumen of the artery is entirely filled with a new formation, which has become canalized by new vessels at D D F; C, blood pigment; E, hyaline material, part of the new formation encroaching on the media at E, and seen elsewhere. (Drawn by Dr. W. L. Wardwell, from a specimen borrowed from Professor W. H. Welch. Magnified 60 diameters.)

Fig. 512.




Traumatic endarteritis. Section from the common carotid of a horse, tied with a broad nerve-ligature, showing at B B the proliferation of the intima. The inflammatory new formation is projected into the lumen of the vessel, and has caused partial atrophy of the media, C; A B, the intima; B B, portion of the intima in the grasp of the ligature; D, the adventitia, slightly changed, with small-cell infiltration. (Drawn by Dr. W. L. Wardwell, from the author's specimen. Magnified about 40 diameters.)

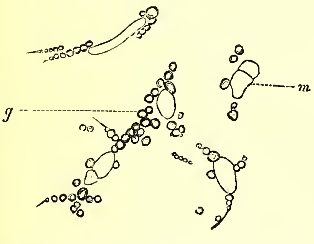
septic matter may pass into the vessel from the surrounding, inflamed tissue, and lead to infarction and pyæmia. The same condition may result from

an extension of inflammation from the surrounding tissues into the arterial wall, as in phagedæna.

*Treatment.*—No unvarying plan of treatment can be laid out for traumatic arteritis. The circumstances of each case must be separately considered. To prevent gangrene, and to guard against hemorrhage, are the indications most to be regarded. Rest, position, quiet, and careful nutrition, are the most important points of treatment.

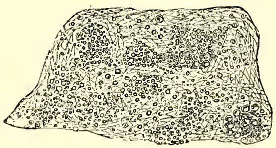
Traumatic arteritis resulting from *causes within the vessels* usually begins as an endarteritis. It may never involve any other tunic than the intima. Many cases of acute traumatic endarteritis are described as idiopathic inflammations. They are none the less due to violence—to the impinging force of the blood-current—for this lesion occurs at those points in the arterial system where the pressure is greatest. Endarteritis and the fatty degeneration resulting from it (Figs. 513, 514) are most frequently seen in the sinus magnus of the aorta, in the transverse segment of the arch of the aorta, at the aortic bifurcation into the two common iliacs, and in the arch of the innominate. The arteries of athletes, which are subjected to prolonged distention resulting from violent muscular exercise, are prone to suffer from this disease.

Fig. 513.




Arteritis with fatty degeneration. Showing fatty degeneration of the intima of the aorta. The nuclei of the normal cells are represented by the larger bodies, one of which is seen at *m*; the smaller bodies, as at *g*, are fatty granules. Magnified 400 diameters. (From Cornil and Ranvier.)

Fig. 514.



A form of fatty degeneration after arteritis. Fatty degeneration of the internal coat of the aorta. Minute yellowish-white patches scattered over the lining membrane of the vessel. A very thin layer peeled off and magnified 200 diameters, showing fat molecules and the distribution of fat in the intima. (From Green.)

Vegetations from the heart may produce endarteritis when they are extensive enough to pass through the aortic valves. Fragments from whatever source, carried along the vessels, produce arteritis at the point of lodgment.

If we examine the intima of an artery which has been the seat of recent endarteritis, it will be seen to be swollen, and thicker and softer than in healthy vessels. The swelling is not usually general and continuous, but occurs in patches or hillocks of quite regular contour, which project into the lumen of the vessel. The intima is usually injected, and reddish in color, though, according to Cornil and Ranvier, when the inflammation has been of a very severe type, the swollen intima is paler than normal. If the inflammation be of recent origin, these patches will present an unbroken surface, but if softening has occurred, the centres of the elevations break down, resulting in erosions or ulcers as they have been styled by some pathologists. Green says that they are due to softening of the intercellular substance, and that the cells and granular matter, becoming loose from this softening, are washed out

by the blood-current. These erosions resemble considerably the superficial erosions found often in the mucous membrane of the stomach. At times they are covered over with a layer of fibrin, which, upon close inspection, is found to be composed of one or more laminæ of fibrillated fibrin, with corpuscular elements entangled in or resting between them.

Beneath the projecting intima is found a mass of inflammation tissue, consisting of embryonic and large anastomosing cells resembling the normal connective-tissue cells of the most external structure of the intima. Hyperplasia of the normal cell-elements is more marked as we approach the inner layers of cells of which the intima is composed, the proliferation growing gradually less extensive as the elastic lamina is neared. This condition is a feature of acute endarteritis, and differs both from the inflammation of the atheromatous process and from syphilitic endarteritis.

This mass of new-formed embryonic tissue is, in all probability, the immediate result of proliferation of the normal cell-elements of the intima. Emigrant corpuscles could only reach this location by traversing the media, for as yet the capillaries have not been projected into the inner tunic. Nor is it probable that leucocytes from the blood-current within the artery involved, migrate through the endothelia into the proliferating mass.

The adventitia does not long remain undisturbed by the pathological changes which have occurred in the intima. It takes on an inflammatory process in a varying degree, and this tunic is found thickened from the proliferation of its connective-tissue cells. If the process be obstinate and persistent, a true arteritis is developed, and all the pathological conditions which have been described on a previous page, may be present.

The media is not greatly altered in the early stages of endarteritis or periarteritis, though in calcification it is apt to be first attacked, as it is likewise in fatty infiltration and degeneration.

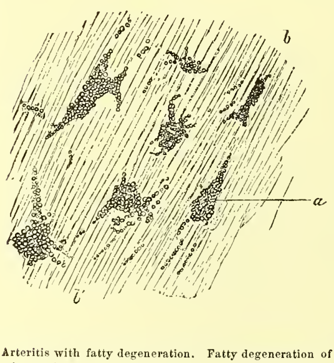
Acute endarteritis may terminate in recovery, leaving no permanent trace of its having existed, or it may pass into a chronic inflammation, which usually ends in fatty degeneration.

This degeneration begins in the endarteritis proper, and travels towards the media. The appearances of an artery which has undergone this change are well shown in Fig. 515.

Fatty degeneration, in its microscopic appearances, resembles very much the atheroma which is, at times, found in the intima. It can, however, by gentle and careful scraping, be removed, revealing the more or less normal tissues underneath, while in advanced atheroma, which involves the deeper structures first, no trace of the normal tissues can be discovered.

*Chronic arteritis* may follow an acute endarteritis, as has been indicated above, although the chronic arterial lesions, as a rule, begin with periarteritis or mesarteritis.

Fig. 515.

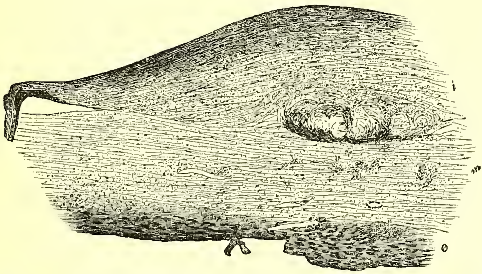



Arteritis with fatty degeneration. Fatty degeneration of the internal coat of the arteries from a thin layer stripped from this membrane. *a*, Fat granules in irregular patches over the surface. The granules have resulted from fatty degeneration of the cells of the intima. *b*, Fibrillated tissue. Magnified 200 diameters. (Cornil and Ranvier.)

II. Non-Traumatic or Idiopathic Arteritis.—The inflammatory process in idiopathic arteritis differs only in degree from that heretofore described as occurring in traumatic arteritis. When not due to syphilis, gout, rheumatism, nephritis, or some dyscrasia, it is usually a part of an inflammation of the tissues immediately surrounding an artery. The process commences in the adventitia, and is analogous to that of traumatic arteritis.

Atheroma and Calcification.—One of the frequent and most serious terminations of chronic arteritis, no matter what may have produced the arterial lesion, is the condition known as atheromatous degeneration (Fig. 516). It

Fig. 516.




Atheroma following arteritis. Section of aorta undergoing the atheromatous change, showing the cellular infiltration of the deeper layers of the inner coat, and consequent bulging inwards of the intima. The new tissue has undergone more or less fatty degeneration. There is some cellular infiltration of the middle coat. *i*, the internal; *m*, the middle; *e*, the external tunic. Magnified 50 diameters and reduced one-half. (Green.)

is essentially a disease of mal-nutrition. It is a senile change, not of necessity coexistent with another disease. It is, as will be proven hereafter, prone to attack the arteries, especially those of the brain, in syphilis, and the larger arteries in other affections. The fatty degeneration of endarteritis is a primary lesion, that of chronic arteritis is secondary. The one is local, the other general. Recovery from the one is possible, and the danger of death is slight. Shreds of fatty material may be carried by the blood and lodged in the cerebral or other remote vessels, doing great injury; but this accident is rare. The possibilities of chronic arteritis with atheroma are always grave. Above the dangers of thrombosis and embolism, and of calcification, are those of aneurism and of hemorrhage. The early recognition of this condition, though exceedingly difficult, is no less important. Atheroma commences in the deeper tissues of the arterial wall, and, advancing in the line of blood-supply, taps the sources of nutrition of the deeper tunics, causing their loss of function, death, and disappearance. It is a true necrobiosis.

The fatty degeneration of atheroma not only involves the innermost layer of the intima (as does that form of degeneration which follows endarteritis), but the muscular-fibre cells undergo complete metamorphosis, while the elastic lamina is the seat of extensive infiltration. In severe cases the work of destruction is complete, the normal tissues disappearing, and leaving nothing but a granular débris.

Atheroma does not usually destroy an extensive area of the intima. The patches may be numerous, but not large. The molecular disintegration is

confined to certain well-defined spots, in the centre of which is found the softened, broken-down "pulp" which has given rise to the term "atheroma." Examined under the microscope, the contents of these pulp-cavities will be found to consist of fat granules, granular corpuscles, and cholesterin crystals, exactly analogous to those sometimes found in abscesses of long duration. Shreds of fibrous tissue may be present. It can be readily conceived how the rupture of one or more of these pulp-cavities, together with the weakened state of the middle and outer coats, would lead to the formation of aneurism. This danger is not so imminent when the inflammatory process has advanced slowly, for the reason that secondary calcification (a conservative process) is more apt to take place. The same may be said of primary calcification where the lime salts are deposited in the "coagulation necrosis" of the media.

The atheromatous and calcareous degenerations may exist in the same location and at the same time. While the cell-structure of the intima is being transformed into granular matter, the fibrillated basement substance nearest the media is the seat of calcareous deposit, at first granular, the granules adhering to form clusters or flakes. At the same time, the nuclei of the muscular-fibre cells are filled in and around with calcareous matter. The entire muscular coat may be converted into a calcified cylinder, or, as is most usual, the process may be confined to isolated patches. In either case, the entire thickness of the wall may eventually undergo the same morbid changes.

When the layer of cells between the calcareous deposits and the blood-current has been broken down by the atheromatous process, it may disappear in the blood and leave the flakes of calcareous matter exposed to view from within. These in turn may be carried away, or they may be undermined by the blood-current and lead to aneurismal pouches by dissection. With atheroma, calcareous degeneration may invade the entire arterial system, the arteries of the extremities becoming brittle and unyielding. The smaller arteries are most apt to be involved, especially those of the brain. This condition is a part of senile malnutrition, and leads to more or less complete occlusion of the vessels, to loss of function of the portions of the body most seriously involved, and to gangrene. It is the commencement of death.

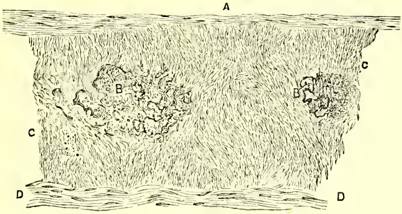
In many cases of atheromatous and calcareous degeneration in the aged, enormous dilatations occur. The dilatation is not uniform, as a rule, but the walls of the dilated artery (usually the aorta and the arteries of the second class) are pouched in many places. The calcareous matter will be found to be thickest in those portions of the wall which are less dilated, while the dilated pouches have undergone a more complete fatty degeneration. This condition is commonly known as *arteritis deformans.*

The middle coat may be in places entirely destroyed, when the changed intima will be joined with the adventitia by a connective tissue new-formation, which (see Fig. 510) contains vessels passing directly to the intima. Loss of the elastic tunic is one of the immediate causes of spontaneous aneurism (Cornil and Ranvier).

This condition of atrophy of the elastic lamina is beautifully shown in Fig. 517, which was drawn from one of my specimens by Dr. Wardwell.

Calcification of arteries has been especially studied by Dr. W. L. Wardwell, of New York City, in Cohnheim's Laboratory. His experience includes examinations made from twenty-five cases at the request of Cohnheim, who assents to his conclusions. Dr. Wardwell says all authorities recognize a morbid change in the arteries known as calcification, and the majority look upon it as a change secondary to atheroma or endarteritis. Few of these recognize a primary calcification not dependent upon a preceding inflammation. This condition is, however, the chief change in the senile calcification

Fig. 517.

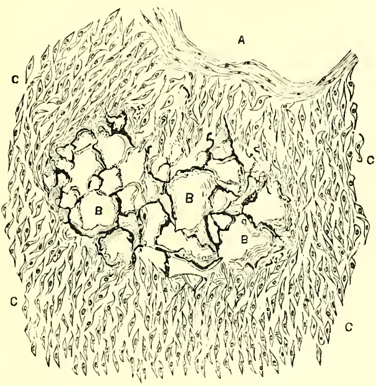



Showing calcareous degeneration of the media. A, intima; C C, media; D, adventitia; B B, calcareous patches. Ulnar artery. Magnified about 60 diameters. (From a specimen prepared by Dr. W. L. Wardwell.)

of arteries. The microscopic appearances of primary calcification are well shown in Fig. 518.

Cohnheim states that in senile arterial calcification, sometimes the media, sometimes the interna (its outermost layer), is affected, and that in them the lime salts are deposited. Moreover, that this deposit of lime takes place here because these tunics have been subjected to the greatest strain.

Fig. 518.




Arteritis with primary calcification. Section from human radial artery, showing at B, primary calcification of the media C. A, the intima comparatively unchanged. (Drawn from specimens prepared by Dr. W. L. Wardwell at Cohnheim's Laboratory. Magnified about 350 diameters.)

Weigert[1] describes a "hitherto undescribed" process known as *coagulation necrosis.* Beginning with the theory of Schmidt concerning the coagulation of the blood, in which the white corpuscles play the leading part, he argues that all tissues have the power of spontaneously coagulating, it being necessary for such an occurrence that the cells should die, give up their ferment and

[1] Virchow's Archiv, Bd. lxxix. S. 87.

fibrino-plastic material, and then become saturated with a fibrinogen-holding lymph. This morbid process he holds may occur in tissues the most diverse in character, as in cheesy glands, infarcts of the spleen or kidneys, tumors, the inflammatory material around parasites, tubercle, etc. Macroscopically, these coagulated spots have a peculiar, stiff appearance, and, microscopically, they are recognized by the fact that the cell nuclei have disappeared, and cannot be made to appear by reagents or by the coloring material used in the microscopical technique.

Weigert states further that to this process belongs a hitherto undescribed tissue-necrosis, viz., the so-called atheromatous degeneration of the aorta and the syphilitic disease of the arteries. There are found in the walls of the vessels many spots with no nuclei, often too small to allow any one to reach a positive conclusion in regard to them. Often, however, these spots are larger and present a fibrinous appearance. These are found not only in the newly formed tissue, but elsewhere, and Weigert attributes to them the chief cause of the inflammatory and hyperplastic tissue-changes which are peculiar to the atheromatous and sclerotic processes; he also declares that the tissues in these spots tend to calcareous degeneration.

Dr. Wardwell arrives at the following conclusions:—

(1) That in the arteries of middle-aged or old persons, there are often found spots of diseased tissue which present all the appearances of having undergone a "*coagulation necrosis.*"

(2) That in these spots there is a tendency to the deposition of lime salts.

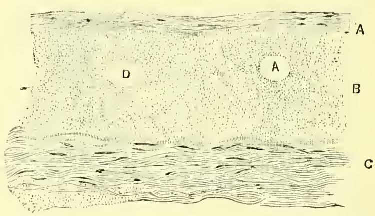
(3) That in primary calcification the media is always first affected, the intima and adventitia only secondarily and by contiguity.

(4) That this change is independent of a preceding inflammation.

(5) That on the contrary these calcified spots act as foreign bodies, setting up a secondary inflammation in their vicinity, and leading sometimes to thickening of the intima.

(6) That one of the changes in atheroma of the arteries is coagulation necrosis, that lime salts are often deposited in such necrotic spots, that the position of such spots is in the intima instead of the media, viz., in the newly formed inflammatory tissue.

Fig. 519.

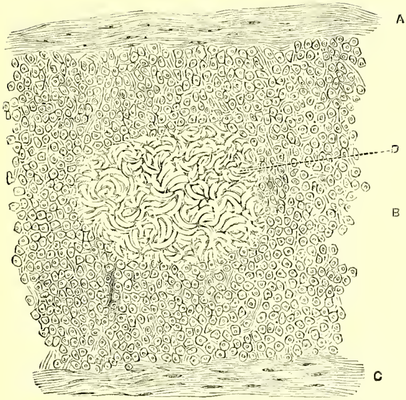



Arteritis with coagulation necrosis. Section from human artery treated with acetic acid, showing at D D, spots of coagulation necrosis which contained calcareous salts before being treated with the acid; A, intima; B, media; C, adventitia. (Drawn from specimen prepared by Dr. W. L Wardwell. Magnified about 40 diameters.)

(7) That primary calcification attacks the small arteries rather than the larger, and especially those portions of the arteries which are subjected to the greatest strain.

These conditions are shown in Figs. 519, 520.

Fig. 520.




**Posterior tibial artery.** Section showing coagulation necrosis. A, intima; B, media; C, adventitia; D, spot of coagulation necrosis. Magnified 360 diameters. (From a specimen prepared by Dr. W. L. Wardwell.)

Syphilitic Arteritis.—Arteritis is a part of the pathology of syphilis. The first danger to life in this disease comes from the changes in the capacity of the arteries. No part of the arterial system is exempt, though the most serious lesions are found in the vessels of the brain, and next in the aorta. They become grave in the larger trunks on account of the atheroma resulting from the syphilitic poison (inducing aneurism), and in the smaller arteries (especially those of the brain) from occlusion or atheroma.

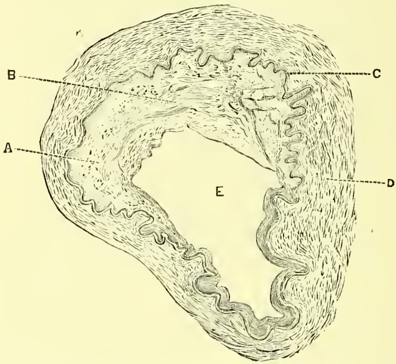
Even in the initial lesion of syphilis (the chancre), according to Biesiadecki, the capillaries of the papillæ have in their thickened walls many nuclei, some of which are seen to project into the lumen of the vessel.

The arteries of the base of the brain, especially the basilar and those at the commencement of the fissure of Sylvius, are often seriously involved. I have seen two cases in private practice in which death resulted from anæmia of the medulla, due to a more or less complete thrombosis of the basilar artery. A patient of Dr. Weber's, to whom I was called, died in my presence. A few days previous to his death he had complained of dizziness, and of a sensation as of insects crawling over the integument of the extremities. Death was quite sudden, and was due to respiratory failure. He became quickly unconscious, and appeared to have lost all sense of the *besoin de respirer*. The respiratory movements were irregular, and co-ordination of movement between the expiratory and inspiratory muscles was seemingly lost. The mode of death was different from anything I had ever witnessed up to that date or have since. At the autopsy, the basilar, just where it divided into the two posterior cerebrals, was found almost completely occluded by a thrombus. There was no other lesion which could have accounted for death. Syphilis had existed for several years.

In the second case, syphilis had existed for nineteen years, with right hemiplegia for the last sixteen years of life. This patient was under my care for nearly five years. She would never consent to take the iodides or any medicine. She was excessively obstinate; her mind was clear up to the time

I last saw her before death, which occurred suddenly one night. I did not see her until life was extinct, but from the description of the mode of death given me by Dr. F. J. Ives, who was present, I was led to express the belief that a similar condition existed as in the case first referred to. On examination, I found a thrombosis of the basilar artery in exactly the same location. Fig. 521 represents a section of the artery near the thrombus. The lumen of

Fig. 521.




Syphilitic arteritis. Section of basilar; E, lumen of vessel about two-thirds filled with new formation at A B; C, media; D, muscular layer and adventitia. From a patient dead from syphilis. (Specimen of the author's, drawn by Dr. Wardwell. Magnified about 40 diameters.)

the vessel is seen to be about two-thirds occluded. The adventitia is slightly thickened, and the cell elements in it are distinctly fusiform, and regularly parallel with each other and with the contour of the adventitia. The wavy elastic layer is easily recognized, and in that portion of the artery in which the syphilitic inflammatory material is deposited, the waves of the media are more numerous and shorter than in other portions of the vessel. In the centre of the mass, occupying a portion of the calibre of the artery, is found a hyaline-looking spot which takes the carmine stain more readily than the general mass of the thrombus. It contains embryonic cells in about the same quantity as the surrounding tissue. The adventitia is not regularly thickened, being three or four times as deep in some portions as in others, and presenting in the section a nodulated appearance. Viewed with a magnifying power of about five hundred diameters, that portion of the arterial wall external to the wavy line (the elastic layer) seen in fig. 521 presents the following appearance:—

In the most external limit of the section of the adventitia, there are found clusters of inflammatory corpuscles, true embryonic cells, round, and larger than the cells found in any other portion of the specimen external to the elastic lamina. These cells are somewhat smaller in size than those found in the new-formed tissue of the intima, though they differ in shape, since those in the intima appear both round and fusiform, while the cells in the outer edge of the externa appear almost invariably round. It may be possible that they are fusiform cells cut transversely in the section, though after careful examination I am led to conclude that they are round. At various points these cells do not exist, the external layer being that of fusiform cells

arranged with great regularity parallel to the contour of the wall of the artery. Where the wall of the vessel external to the elastic lamina is thickest, these spindle cells are more numerous and have a greater transverse diameter than at the narrower portions, where they seem to have elongated and become thinner—seemingly a true process of fibrillation and contraction of embryonic (inflammatory) cells.

Continuing the examination further inwards, as the white, wavy, elastic zone is crossed, just within and almost in exact apposition with this is a somewhat irregular and thin layer of cells, fusiform in section, varying in depth from a single row to two or three rows, and in some points entirely absent. These are doubtless a remnant of the original endothelia of the intima; just internal to these, and in fact continuous with them, is the great mass of new-formed, inflammatory tissue which juts into the lumen of the vessel. This mass is composed of large, mostly fusiform, cells, distinctly nucleated and occupying about as much space as the intercellular substance in which they are imbedded. (The space seen in some portions of the section between the wavy elastic line and the cell mass in the lumen of the vessel is due to cleavage or splitting off in making the section.) The following conclusions I have arrived at from the study of this case:—

(1) The elastic tunic is very slightly if at all changed by the inflammatory process in syphilitic arteritis. If there be any change, it is due to a corrugation or wrinkling of this tunic in the process of contraction.

(2) The external coat is irregularly thickened, and appears nodular on transverse and longitudinal section. This thickening is the result of the syphilitic inflammatory process, and the external layers of inflammatory corpuscles differ from those (and the greater portion) which form the bulk of the changed external tunic.

(3) The chief lesion in syphilitic arteritis is situated in the intima, and is due in the main to active proliferation of the normal cells of this tunic.

Syphilitic arteritis has been made the subject of special study by Cornil, Heubner, Greenfield, Barlow, Buzzard, Davidson, Simes, White, and others.

Greenfield, in the Transactions of the London Pathological Society for 1877, gives an analysis of twenty-two cases of visceral syphilis. His cases and report are so instructive, and give evidence of such careful study of this important subject, that I quote them almost in full.

Of the 22 patients, 13 were females, 9 males. Their ages varied from twenty-three to fifty years. Of the females, four were between the ages of 23 and 25, one was 35, one 38, the remainder between 40 and 50. Of the males, four were between 30 and 40, the rest between 40 and 50.

These patients did not all die from syphilis, some perishing from other and concomitant diseases. Of those who died from the effects of syphilis, the greater number were comparatively young. Of the four females under 25 years of age, two died from the effects of thrombosis of the cerebral arteries, one from syphilitic disease of the larynx, and one from accident. Of the six males under 40, one died from syphilitic disease of the cerebral arteries, one from gummata of the brain and dura mater, one from pneumonia due to syphilitic disease of the larynx and trachea, one from renal disease consequent upon stricture, and another by accident.

The following table from this close observer is so interesting in the demonstration which it gives of the frequency of arterial lesions in the later stages of syphilitic disease, that I copy it entire.

## Cases of Visceral Syphilis observed in Post-mortem Room of St. Thomas's Hospital during the Years 1875–6.

| No. | Sex. | Age. | Occupation. | Date of infection. | Cause of death. | Organs affected by syphilis and nature of affection. | Lardaceous degeneration. | Kidneys. | Arteries. | Skin. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | F. | 47 | Married | ...... | Peritonitis following colotomy for relief of syphilitic stricture of rectum. | Rectum, extensive ulceration and thickening. Liver, some small punctured cicatrices. | None. | Nil. | Nil. | Not noted. | |
| 2 | M. | 42 | Blacksmith | ...... | Acute pneumonia secondary to renal disease. | .............. | None of liver or spleen; adv'd in kidneys, intestines not noted. | Advanced lardaceous degeneration. | Slight atheroma of aorta and of cerebral arteries. | Rupial eruption and scars of same. | |
| 3 | F | 38 | Married | ...... | Slight phthisis; pleurisy and pneumonia; thrombosis of pulmonary artery. | Ulceration of rectum and vagina; small gummatous tumor in corpus striatum. | | | | | |
| 4 | M. | 38 | Carpenter | ...... | Bronchopneumonia. | Extensive disease of palate, necrosis of cricoid cartilage and nearly all the rings of trachea; perihepatitis. | Very slight of kidneys only. | Slight lardaceous degeneration. | Not noted. | Not noted. | |
| 5 | F. | 25 | Married | ...... | Thrombosis of cerebral arteries. | Extensive necrosis of nasal and upper jaw bones; gummata in liver, spleen, and kidneys; thickening of middle cerebral artery. | None of liver or spleen. | Gummata and infarcts from arterial obstruction. | Atheroma of aorta; cerebral artery with syphilitic thickening. | Nothing to be discovered on careful examination. | Path. Trans., vol. xxvii. p. 311. |
| 6 | M. | 34 | Sawyer | ...... | Meningitis, and gummata in brain. | Osteo-sclerosis of skull, gummata in dura mater, gumma in brain; disease of cerebral arteries. | None. | Congested. | Slight atheroma at origin of aorta, none elsewhere; cerebral. | Not affected. | Case 1 of disease of cerebral arteries, gummata in brain and dura mater shown. |
| 7 | F | 43 | Married | ...... | Thrombosis of cerebral arteries. | Cicatrices in liver; disease of cerebral arteries. | None. | ........ | Cerebral. | ........ | Mitral and tricuspid stenosis, see Path. Trans., vol. xxvii. p. 113. |
| 8 | F. | 48 | Married | ...... | Obstruction of left internal carotid and middle cerebral arteries by clot (? thrombosis or embolism). | Gumma in wall of heart; gummata and cicatrices in liver; gummata in spleen. | None. | Degeneration. | Atheroma of aorta with very prominent patches; middle cerebral ? nature of affection). | Not affected. | Specimen shown. |
| 9 | M. | 43 | Carman | 24 years | Meningitis from perforation of dura mater by gumma growing in occipital bone. | Very extensive disease of liver perihepatitis, cicatrices, and gummata larynx, necrosis of cricoid bones, peculiar affection of ends of long bones. | None of kidneys. | Congested. | Not noted. | | |
| 10 | F. | 24 | Married | Probably short, in secondary stage | Mitral stenosis; softening of brain ? from vascular disease. | Secondary ulcerations of tonsils and fauces; minute gummata in dura mater. | None. | ........ | ? Disease of cerebral arteries. | | |
| 11 | F. | 50 | Housekeeper | ...... | Diffuse abscess of thigh; pyæmia. | Gumma in liver: old scars on tonsils. | None. | ........ | Atheroma of aorta; external atheroma of cerebral vessels. | Nil. | |
| 12 | M. | 47 | Cutler | ...... | Gangrenous ulceration of bronchi, and gangrenous pneumonia. | Ulceration of fauces, tonsils, pharynx, larynx and trachea; necrosis of cricoid and part of thyroid cartilages. | None. | ........ | ........ | Rupial scars. | |

| No. | Sex. | Age. | Occupation. | Date of infection. | Cause of death. | Organs affected by syphilis, and nature of affection. | Lardaceous degeneration. | Kidneys. | Arteries. | Skin. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | M. | 40 | Soldier | ...... | Opium poisoning. | Puckered cicatrices in lower lobe of right lung; healed gumma in spleen, great enlargement and induration of glands in left groin. | None. | Large (20 oz.); greatly congested | Extreme atheroma of aorta; large, prominent, gelatinous patches. | Large irregular scar on thigh; nature uncertain | |
| 14 | F. | 35 | Servant (unmarried but had had child). | ...... | Renal dropsy. | Enlarged and indurated glands in right groin; old disease of pharynx with cicatricial contraction, large mass of gummata and cicatricial fibrous tissue in liver. | Advanced of whole gastro-intestinal and vaginal mucous membranes & of kidn'ys | Lardaceous and fatty. | Patches of endarteritis deformans in abdominal aorta; none of thoracic. | No scars or nodes. | Liver shown. |
| 15 | M. | 46 | Plasterer | ...... | Dilated heart; dropsy. | Cicatrices in liver; advanced affection of skin. | None. | ........ | Slight atheroma of aorta. | Rupial ulcers on legs; condition of scrotum resembling elephantiasis. | |
| 16 | F. | 23 | Single, but had one child | 3 to 4 years | Asphyxia from removal of tracheotomy tube. | Larynx, extensive infiltration of tissues, abscess over thyroid cartilage. | None. | Congested. | General atheroma of aorta. | Nil. | Lived with a man who had a skin eruption, and the child had an eruption when a few weeks old |
| 17 | F. | 46 | Widow | ...... | Hæmoptysis in rapid phthisis. | Cicatrices and gumma in liver; lungs? | None. | Slightly granular. | Atheroma of aorta. | Nil. | |
| 18 | F. | 47 | Servant | ...... | ........ | Atrophy of right lobe of liver from perihepatitis and gummatous infiltration. | Of kidneys, spleen, and intestines. | Lardaceous degeneration. | | | |
| 19 | F. | 25 | Unmarried, but cohabiting, and had one child | ...... | Fracture of cervical spine. | Syphilitic ulcers of legs; cicatrices in lungs; calcified nodules; probably gummata in liver. | None. | ........ | Atheroma. | Nil. | |
| 20 | M. | 30 | Sailor | ...... | Cystitis and pyelonephritis from stricture of urethra. | Cicatrices in liver. | None. | | | | |
| 21 | M. | 34 | Plate layer | ...... | Thrombosis of cerebral arteries. | Extreme disease of cerebral arteries; dura mater; larynx. | None. | ........ | Marked atheroma. | Nil. | Case 2 of disease of cerebral artery; vessels, dura mater, and larynx shown. |
| 22 | F. | 50 | Servant (single) | ...... | Hemiplegia due to softening of brain from thrombosis; cystitis, pyelonephritis, and peritonitis. | Extensive but irregular thickening of cerebral arteries; puckered cicatrices in lower lobe of right lung only, without pleural adhesions. | None. | Right, with multiple suppurative nephritis (surgical kidney); left, normal, no disease either acute or chronic; not lardaceous. | Aorta somewhat atheromatous, not advanced; carotids also atheromatous. | Large, irregular, much pigmented scars on left thigh and leg as of old syphilitic ulcers. | |

It will be observed that of the total of 22 cases, the condition of the vascular system is noted in all but 6. In one case there was no lesion of the arteries. In the remaining 15 cases the arteries were more or less seriously

involved. In other words, out of 16 cases in which the condition of the arteries was noted, in 15 these vessels were diseased.

The author says that the condition of the aorta and large vessels as regards atheroma is of importance in connection with the dependence of aneurism upon syphilis, and that as regards the smaller vessels, the nature of the disease of the cerebral arteries is of the greatest interest. In the cases heretofore noted in the table, where the kidneys were diseased, the effect of syphilis in producing the atheroma might be questioned. In three females (cases 5, 16, and 19), aged 23, 25, and 25, there was marked atheroma of the aorta. In one, the atheroma was general in the aorta and its larger branches, the condition being that of diffused, irregular swelling, with but little fatty degeneration. The kidneys in this case were structurally healthy. In one female, aged 25, in the first part of the arch of the aorta were several patches, rounded, prominent in the centre, and thicker than usual. On section these appeared homogeneous, and presented scarcely any fatty degeneration. Throughout the rest of the aorta there was general atheroma with no peculiar characters. In another female, aged 35, there were large patches of endarteritis deformans in the abdominal aorta. In this case there was lardaceous degeneration of the kidneys.

In several other cases there was marked atheroma, and in most cases where there was no renal disease the patches were much raised, sometimes almost hemispherical, at other times with sharply defined edges of gelatinous appearance and pearly lustre; and on section there was but little fatty degeneration or calcification.

Whether in these cases the disease would have gone on to the formation of aneurism, cannot of course be decided; but it is evident that a marked tendency to the occurrence of endarteritis deformans at an early age, and in an advanced degree, exists in visceral syphilis. This is especially noticed upon comparing the condition, in these cases, with that in a large number of other patients of the same age who have died from all forms of disease, when it is found that in no others was any atheroma observed apart from the coexistence of very marked renal disease. It is probable that the absence of cases of aneurism from this series is purely accidental, for in a number of other cases Dr. Greenfield has found very marked syphilitic visceral disease in cases of aneurism occurring at an early age.

The cerebral arteries were very markedly affected with syphilitic disease in five cases, and in a sixth were probably diseased.

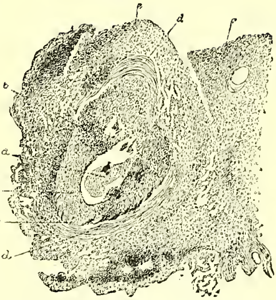
As to the pathological changes which syphilitic arteritis causes, they are given by Dr. Greenfield in two cases of disease of the cerebral arteries.

The specimens were taken from the middle cerebral and basilar arteries. They are typical and probably represent two different stages of the process. "In the first case the disease is seen in the earlier form, in which it consists almost entirely of a cell-growth which has as yet undergone but little organization. In the second case considerable changes have occurred, and a large part of the new growth is converted into more or less fully developed connective tissue. In the specimen sketched in Fig. 522, the artery is seen to be somewhat irregular in shape, this being due to obliquity of the section. The lumen (*a*) is very small, but is clearly defined, rounded, and free from thrombus.

The outer coat appears somewhat thickened, and is infiltrated in continuity with the pia mater (*f*). The muscular coat (*d*) is distinctly seen at the upper and lower parts of the section, elsewhere being somewhat infiltrated, and not clearly separated from the adventitia. The fenestrated membrane is clearly seen at *b*, where it is indicated by the dark lines; it could be clearly traced on altering the focus, all around the vessel, lying as usual immediately internal

to the muscular layers, and separating them from the inner coat. It is to that part of the vessel lying between *a* and *b* (Fig. 522) that attention must be specially directed, the thickened inner coat constituting the essential feature and the peculiarly characteristic element of the morbid change. With a higher power, the thickening of the inner coat is seen to consist entirely of a cell-growth which closely resembles granulation tissue. In the deeper parts, nearest the fenestrated membrane, the cells appear to be flattened, running parallel with the elastic layer, growing, however, more irregular in disposition towards the centre. No distinct transition line can be discovered between this deeper layer and the central part, in which, however, the cells appear to be larger, often branching and more loosely arranged, with more numerous capillaries running amongst them. Many of the cells in the intermediate layer appear to be rounded, but it is not improbable that they are fusiform cells cut transversely. In many parts of the thickened intima the capillaries are numerous and of large size.

Fig. 522.

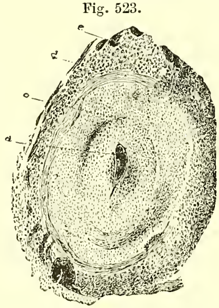


Syphilitic arteritis. Shows section of small cerebral artery near a gumma, magnified 30 diameters. *a*, lumen of vessel; *b*, boundary of inner middle coats; *c*, thickened inner coat; *d*, middle coat; *e*, external coat; *f*, infiltrated pia mater. (After Greenfield.)

Toward the lumen of the vessel the cells again assume a flattened or fusiform shape, and several layers of these cells closely packed together form the innermost part of the new growth, the most internal, superficial layer (that in immediate contact with the blood-current) forming a continuous layer, which corresponds in its functions to normal endothelium.

The other specimen (Fig. 523) appears to have undergone different changes. The coats of the vessel are enormously thickened, and the lumen of the vessel correspondingly diminished, so as to become a narrow chink (the section is somewhat obliquely made). The thickening of the wall is found to present great variations, at points of the vessel not further apart than one-twelfth of an inch, other sections at that distance from the one represented in the cut not being more than one-half as thick, the external diameter of the vessel remaining almost constant. The adventitia (*e*) is slightly thickened and infiltrated by a cell-growth. The muscular coat (*d*) is of pretty uniform thickness, except at some points where invaded with cell-infiltration from the adventitia. The inner coat is enormously thickened, and presents the appearance of two concentric rings, the boundary between which is more or less defined. Examined with a higher power (Fig. 524), the lumen of the vessel is found free from thrombus. The membrana fenestrata is well defined. The muscular layer presents very much its normal appearance at some points, except that the fibre-cells are somewhat granular. At some points it is encroached upon by the cell-growth from the outer coat, between which and

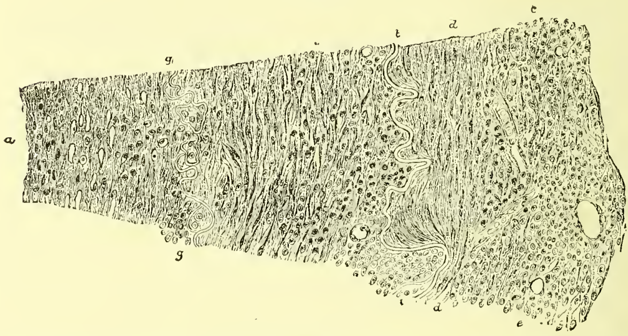
Fig. 523.



Syphilitic arteritis. Section of small artery of cerebellum, magnified 30 diameters. *a*, lumen of vessel; *c*, thickened inner coat; *d*, muscular coat; *e*, outer coat. (After Greenfield.)

the muscular coat there is no distinct line of demarcation. The outer coat is somewhat irregularly thickened by cell-growth, which is especially abundant around the vasa vasorum, which are very numerous and much more developed than usual. At some points small vessels traverse the muscular and elastic coats, going into the deeper portions of the thickened intima.

Fig. 524.



Syphilitic arteritis. Segment of the preceding specimen, magnified 170 diameters. *a*, lumen of vessel; *b*, fenestrated membrane; *a*, *c*, thickened intima; *d*, muscular coat; *v*, adventitia; *g*, new-formed imperfect elastic lamina. (After Greenfield.)

The inner coat measures twice the thickness of the outer and middle coats together. Starting from the fenestrated membrane, in its neighborhood there is found a rather abundant cell-growth traversed by capillaries. Nearer the intima is found a fibrous tissue, formed of elongated, fusiform cells and delicate, interlacing fibrils of connective tissue, the whole constituting an imperfectly developed fibrous tissue. Internal to this are seen more numerous, rounded cells, some of which are of larger size. Nearer to the lumen are seen elongated, oval nuclei, smaller and more highly refractile, and more closely packed together. It will be seen, by reference to my own case already given, that in the changes which occurred in the intima it was analogous to Dr. Greenfield's first case, while in the irregular, nodulated condition of the muscular layer it was analogous to his second.

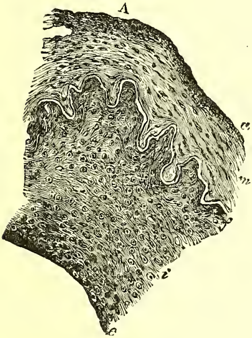
In cases of constitutional syphilis, W. R. Gowers has studied the development of syphiloma in its relations to the arterioles. He concludes that the inflammatory material travels in the line of the vessels in the membranes of the brain. "These processes (of inflammatory matter) follow the course of vessels, and an examination of the points of the processes shows that the extension of the growth occurs along the perivascular canals."

According to Greenfield, the inflammatory matter in and around the perivascular canals in syphilis is entirely different from that in tubercular infiltration of these canals.

In vessels examined by Barlow, the same changes are reported as those given above (Figs. 525, 526). The adventitia and muscular coats were more or less affected, "but obviously the principal changes have taken place in the intima." Davidson and Buzzard are led to the same conclusions with the foregoing, as is Green in his "Pathology and Morbid Anatomy."

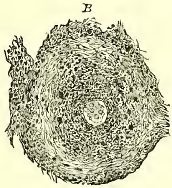
Heubner[1] holds that the process of new cell-formation in the intima, which has just been described at length, is due to the direct irritation of the current of the poisoned blood upon the endothelia. The inflammation progressing, proliferation of the intima increases, projections into the lumen occur, and

Fig. 525.




Syphilitic arteritis. Transverse section of a segment of the middle cerebral artery of a syphilitic patient. *i*, the thickened intima; *e*, the endothelium; *f*, the fenestrated membrane; *m*, the muscular coat; *a*, the adventitia. (From Barlow's Specimens, Green's Pathology.)

Fig. 526.




Syphilitic arteritis. Section from a small artery of the pia mater cut transversely, showing the inner coat much thickened, a diminution of the lumen of the vessel, and a considerable infiltration of the adventitia. A clot is seen to occupy a great part of the lumen of the vessel. (From Barlow's Specimens, Green's Pathology.)

narrowing or occlusion is the result. As the endothelial layer is lifted by this undermining, inflammatory process, a lateral projection into the lumen of the vessel (a vegetation) takes place, which may be the starting point of a thrombosis, or of cerebral anæmia. Heubner holds that these lateral, projecting vegetations of the internal membrane are pathological conditions appertaining especially to syphilitic arteritis.

It is asserted that syphilitic arteritis can be diagnosticated from atheroma during life. Lancereaux, according to Simes and White, in their edition of Cornil on Syphilis, says that the difference can be recognized chiefly by the occurrence of thrombosis in young subjects, without evidence of disease in other arteries. The knowledge that the patient has syphilis is a valuable aid to differentiation. (It is not difficult to agree with Lancereaux in this conclusion.) Moreover, atheroma is developed especially in the larger arteries, while the syphilitic process is found in the smaller, and by preference in the cerebral vessels; and, lastly, the young suffer from syphilitic arteritis more frequently than from atheroma.

I agree with the last-named observer that the differential diagnosis during life of the two arterial lesions, syphilitic and atheromatous, is extremely difficult, if not impossible. Moreover, these lesions very often exist at the same time.

Of the 22 cases quoted in the table from Greenfield, after excluding seven in which the condition of the arteries was not noted, we find that of the remaining fifteen, in thirteen there was atheroma of the aorta (and some of the

[1] Cornil on Syphilis.

smaller vessels), in one there was arteritis deformans, and in only one of the cases noted was there no coexisting atheroma.

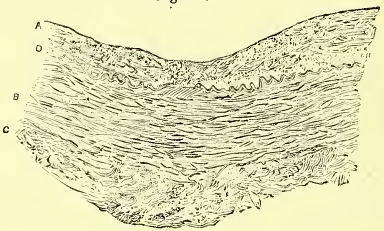
Since atheroma is a disease resulting from malnutrition of the vessel walls, and since syphilis is a blood-impoverishing disease, it can be easily conceived that atheroma of the larger arteries would occur in the later stages of syphilis, after the arteritis proper to this disease had been established in the smaller and remote arteries.

While the atheromatous process commences in the deeper tissues, advancing in the line of blood supply to the arterial walls, producing fatty infiltration of the elastic tunic and degeneration of the muscular fibre-cells and of the cells of the intima, and while in severe cases the normal tissues disappear, and the vessel dilates to such an extent that the artery (despite the temporary thickening of its walls, due to the inflammatory process) is much larger in calibre than normal, the syphilitic process is especially prone to attack the intima, and, while it is not entirely confined in its depredations to this coat, the changes it produces are never as constant in the other coats as in this.

Atheroma causes a weakening of the walls and general or saccular dilatation; syphilitic arteritis tends to more or less complete occlusion of the vessels, due to inflammatory cell new-formation (chiefly) of the intima. And while the inflammatory process may be somewhat aided by the direct irritation of the poisoned blood current passing along the vessel in contact with the intima, I believe that this inflammatory poison travels chiefly in the line of blood supply through the vasa vasorum.

RHEUMATIC ARTERITIS.—Arteritis may occur in connection with acute rheumatism. Bryant states that this is a rare form of disease. Rheumatic endo-

Fig. 527.




Arteritis with chronic nephritis. Section from posterior tibial artery of patient dead from Bright's disease, showing at A great thickening of the intima, the result of chronic endarteritis. The elastic lamina D unchanged. The muscular layer B slightly thickened. C, adventitia greatly thickened at places by small-cell infiltration. Drawn from specimens prepared by Dr. W. L. Wardwell at Cohnheim's Laboratory. (Magnified about 40 diameters.)

carditis is not so rare, and it is possible that endarteritis may exist in the aorta in many cases of endocarditis. This and the arteritis of gout and nephritis (Fig. 527) belong to the domain of medicine, rather than to that of surgery, and will not therefore be considered in this work.

The *treatment of arteritis* resolves itself simply into the treatment of the disease of which it is a part. It would be useless to increase the length of this article by a recapitulation of the various methods and remedies which have been employed. If the pathogeny and pathology of the affection are understood, its therapy is not difficult.

Arterial Thrombosis and Embolism.—Though not as frequent as in phlebitis, thrombosis and embolism often result from arteritis. The pathology of thrombosis has been given in the section on phlebitis. The process in the arteries is closely analogous to that in the veins.

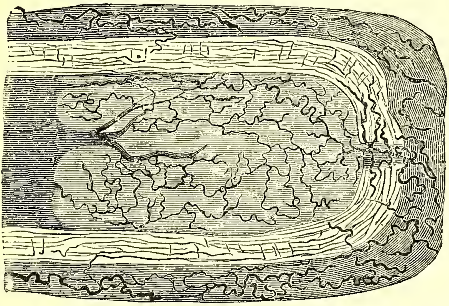
The perfect type of thrombosis from acute, traumatic arteritis, is found after the application of an occluding ligature around an artery.

By reason of arrest of the blood current and disturbance of the equilibrium normally existing between the blood and the containing vessels, coagulation takes place on the cardiac side of the ligature, extending back as a rule to the first collateral branch. Immediately following the injury to the vessel, the process of inflammation—true arteritis—commences. The tension of the ligature to such a degree as to divide the inner or middle coat, or both, is unnecessary. I have tied arteries (carotid and subclavian) in human beings, and in horses and dogs, and have specimens which demonstrate successful occlusion of the vessel without division of either of the three tunics.

Scarpa advanced this idea years ago, but surgeons generally have decried it. None the less is it true, and I am fully convinced by experience that it is safer than the division of one or two coats of a vessel by tightly drawing a narrow, cutting ligature around an artery.[1]

The coagulation thrombus disappears by fatty degeneration. The permanent occlusion is due to new formed tissue springing from the normal cells of the intima. O. Weber held that the clot became organized into a true tissue, into which bloodvessels were projected from the vasa vasorum (Fig. 528).

Fig. 528.



Longitudinal section of the artery of a dog fifty days after the ligature. Clot injected. Magnified 40 diameters (After O. Weber.)

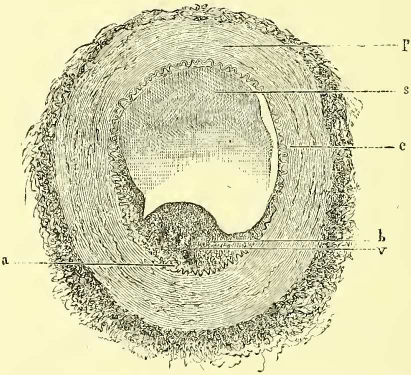
But Cornil and Ranvier long since disproved this assertion of Weber. Bubnoff held that the white blood corpuscles emigrated through the walls of the ligatured vessel, permeated the clot, and caused its organization, but Durante (Cornil and Ranvier) has demonstrated that the leucocytes only traverse the walls of the vessel when this has been tied with a double ligature causing a death of the included vessel, and that the leucocytes travel through this dead tissue. They do not permeate the walls of an otherwise healthy artery which has been tied with a single ligature.

Cell proliferation takes place rapidly in the intima; granulation buds pro-

[1] See cases by the author in Archives of Medicine, New York, June, 1882.

ject into the territory occupied by the clot (Fig. 529); bloodvessels derived from the vasa vasorum permeate the projecting granulation tissue, invade the clot, meet with live vessels from the opposite side, and join with these in a continuous circulation; the embryonic tissue organizes, gradually contracts (process of cicatrization), and the walls of the vessel are permanently occluded by this fibrillation. Afterwards, the new formed vessels disappear to a great degree, being obliterated by the contracting tissues.

Fig. 529.




Traumatic endarteritis. Transverse section of the femoral artery of a dog eight days after the application of a ligature. *e*, the elastic lamina; *p*, the media; *b*, granulation bud projecting from the intima into the lumen; *v*, new formed vessel running through the inflammatory tissue. At *a*, the elastic layer has partly disappeared. Magnified 30 diameters. (From Cornil and Ranvier)

Fig. 512, from a section of the carotid of a horse, shows how this rapid proliferation of the normal cells of the intima occurs when the intima has not been divided. There was in this case simply an irritation of the intima, a bruising, the result of jamming together the opposing surfaces of the intima by means of a broad (not cutting) ligature.

Indeed, if argument be needed to strengthen this position, how unanswerable is this: that this process of proliferation of the intima into granulation projections is so extensive in some case of peri-arteritis that occlusion by thrombosis occurs. Here surely there is no division of the coat, not even contact of surfaces, but an inflammation of the intima resulting from pre-existing peri-arteritis.

Thrombosis from acute arteritis is rare. Chronic arteritis is not unfrequently the cause of occlusion. Syphilitic arteritis is apt to develop thrombosis of the cerebral arteries. Arterial thrombosis (excluding the vessels to the brain and walls of the heart) is not as dangerous to life as venous thrombosis.

The process is usually so gradual that the collateral circulation is established before occlusion of the main trunk occurs. This may indeed escape observation until the enlarging superficial arteries attract attention.

I have elsewhere reported a case illustrative of this fact. The occlusion was the result of chronic arteritis with calcareous degeneration. The popliteal was occluded from its bifurcation into the anterior and posterior tibial

vessels, and back to the origins of its superior articular branches, and the only chance of collateral circulation was through the anastomotica magna of the superficial femoral, together with the recurrent tibial and a muscular branch from the upper part of the popliteal. The circulation through these was perfect and sufficient.

The thrombus formed under such conditions differs from the organized thrombus at the seat of a ligature, inasmuch as the passing blood-current furnishes fibrin-making white corpuscles with accompanying fibrin-deposit in the one, while this cannot occur after a ligature is applied.

The detachment of particles of thrombi (emboli) and the accidents resulting therefrom do not fall within the province of this article. They are fully discussed in the articles on pyæmia, gangrene, etc.

The causes of thrombosis may be summed up as follows: (1) Occlusion of the vessel as by a ligature. (2) Inflammation of the intima (arteritis). (3) Dilatation of the vessels (as in aneurism). (4) An abnormal condition of the blood. (5) Heart failure. (6) Narrowing of the calibre of an artery by pressure.

## Vascular Tumors.

We may recognize six varieties of vascular tumor, apart from true aneurism. These are: (1) Arterial varix; (2) Cirsoid arterial tumor, or cirsoid aneurism; (3) Arterial cutaneous tumor; (4) Capillary cutaneous tumor; (5) Venous cutaneous tumor (these three varieties are usually classed together under the name of angeiomata); and (6) Venous varix, or simply varix (varicose vein).

Arterial Varix may be defined as a dilatation and elongation of an artery of the second magnitude (as the external iliac or common carotid), of the third (as the external carotid or posterior tibial), or of the fourth (as the temporal, facial, superior thyroid, or palmar branches of the radial and ulnar). Cruveilhier has reported a case of *arterial varix* of the external iliac artery. I have made one dissection of *arterial varix* of the superior thyroid artery, in which this vessel was greatly elongated, and as large as the external or internal carotid. It was tortuous, but not sacculated, the dilatation being general. Tillaux[1] reports a case of *cirsoid aneurism* of the hand with dilatation of the arteries of the forearm and humeral region.

*Treatment.*—Arterial varix may be treated by compression, or by the ligature, when such a procedure becomes necessary. In a case which I saw after the patient's death, and in which the superior thyroid artery was involved, the ligature would have been advisable. The artery was in a healthy condition, with the exception of its increased length and calibre.

When connected with *cirsoid arterial tumors*, the solidification of these by ligature, cautery, or injection, will usually cure or palliate the arterial varix.

Cirsoid Arterial Tumor, or Cirsoid Aneurism.—The *Cirsoid Arterial Tumor*, I would define, after Robin and Gosselin, as being an elongation and dilatation of the terminal subcutaneous arterioles (normally of a diameter of about $\frac{1}{50}$ of an inch). These tumors may be general or circumscribed. A single arteriole may be affected, as shown in a drawing in the Museum of St. George's Hospital, copied in Holmes's System of Surgery, or many arterioles may be involved, as in Mussey's remarkable case, and in others included in the accompanying table (page 358).

[1] Gaz. des Hôpitaux, 1882, p. 1083.

The term *cirsoid aneurism* was introduced by Breschet, in a paper presented to the Academy of Medicine, at Paris, in 1832. By him it was applied to the condition of varicosity involving the larger arterial trunks, their branches, and the terminal arterioles. Robin, at a later date, introduced the name of *cirsoid arterial tumors*, and defined these as varicosities of the terminal (subcutaneous) arterioles.

English writers have adopted the term employed by Breschet. By them it is usually considered "a form of disease which consists in a simultaneous elongation and dilatation of an artery. The structure of its wall exhibits in the beginning no alteration, although the coats become thinned during the progress of the enlargement. The middle coat of the artery is especially affected. It becomes pale and thin, so that the arteries look like veins. The dilatation is commonly equal throughout the circumference of the artery. In more severe cases the artery is greatly dilated, and presents unequal, saccular pouches, which are in fact so many true aneurisms, projecting usually towards the surface of the skin" (Holmes).

Gosselin[1] adopts the nomenclature of Robin, and considers the disease heretofore known as cirsoid aneurism as only involving the terminal arterioles. The causes of *cirsoid arterial tumors* are not positively known. They occur most frequently upon exposed surfaces of the body, as on the neck, head, and hands. The face and head are most frequently the seat of all forms of vascular subcutaneous and cutaneous tumors. Excluding those of the orbit, I have collected more than 90 cases in which the carotid arteries were tied for these lesions.

Polaillon reports fourteen cases of cirsoid aneurism of the hand. The influence of exposure of an unprotected surface to atmospheric changes is worthy of consideration. Either peripheral or central disturbances of the functions of the vaso-motor nerves may lead to loss of tone in the muscular walls of the arteries. Frost-bite and blows have been mentioned as causes of cirsoid aneurism. Berger reports a case of cirsoid tumor of the hand caused by irritation, from constant pressure of an instrument which the patient used in his trade. The disease may also be congenital, or may result from the increased growth of a cutaneous nævus. Gosselin cites two cases of this kind. He holds that the presence of nævus indicates a congenital predisposition to vascular dilatation, and is not sure but that a subcutaneous arterial dilatation, at first not recognized, may exist simultaneously.

According to Holmes, cirsoid arterial tumor occurs most frequently between the ages of fifteen and thirty. Wardrop's patient, whose case is given by Gosselin as one of cirsoid arterial growth, was operated upon the sixth week after birth. Wardrop gives this case as one of "erectile tumor." Chelius operated for "aneurismal varix of the temporal region" in a child of twelve months.

*Symptoms.*—The *clinical history* of cirsoid arterial tumors does not commence with the pathological changes which occur in the terminal arterioles. Dilatation begins before there is any appreciable projection of the skin, or pulsation, or twisting of the arterioles. At a later period, the physical signs are present, and the diagnosis easy. Direct pressure will arrest the pulsation and empty the tumor. The consistency of these tumors varies with the amount of the connective tissue developed around the arterioles, as a result of the inflammatory process. Petit describes the sensation imparted to the palm of the hand pressed upon an arterial cirsoid, as similar to the vermicular motion of a mass of earth-worms.

With the stethoscope, a bruit de souffle is distinctly audible. Pain is not

[1] Archives Générales de Médecine, 1867.

constant, and is only due to the pressure of the growth upon the cutaneous nerves. As the tumor progresses in size, more marked inflammatory changes occur; adhesions to the skin take place; and ulcerations, with alarming hemorrhages, are not infrequent. In some instances, especially in cirsoid tumor of the scalp, pressure of the growth upon the calvaria may interfere with the nutrition of the skull.

*Treatment.*—It may be said of the treatment of cirsoid arterial tumors, in common with arterial, capillary, and venous cutaneous tumors, that no method is as safe or sure as direct local treatment. The study of a large number of cases leads me to this conclusion. For a long time deligation of the main trunk or trunks was the favorite practice. Sometimes this was done to arrest hemorrhage due to ulceration or accident, in some few cases to arrest hemorrhage after or during an attempt at removal, but most frequently the intention was to cut off the blood-supply. Since the vast majority of vascular tumors occupy the neck, face, and scalp, the carotids have been often tied in the treatment of these growths. In my "Essays in Surgical Anatomy and Surgery,"[1] I have collected 803 cases of deligation of the carotid. Not including 60 cases of intra-orbital aneurism (pulsating vascular tumor within the orbit), there were 98 cases of ligature of the carotid for vascular growth above the clavicle, and chiefly of the head. The results are not such as to encourage the careful operator in a repetition of the procedure.

By reference to the Table accompanying this paper, and which, with the exception of a single case (that of McBurney), is taken from my work on the Arteries, the results may be studied in detail. At the risk of repetition, and in order to emphasize the above remark, it may be said that of 73 cases in which the common carotid was tied, almost 30 per cent. proved fatal, and the proportion of patients that were cured out of 51 who recovered from the operation (about 50 per cent.), is not encouraging. Deligation of a main trunk, I am convinced, is only justifiable in case of hemorrhage which cannot be arrested by any other means, or after all other methods have been essayed.

As to the efficacy of the ligature of the parent trunk to arrest dangerous and accidental hemorrhage, the case of Dr. Edward Bradley, of New York, may be cited. In the attempt to remove a large vascular tumor of the parotid and submaxillary region, such alarming hemorrhage occurred that it became necessary to tie the common carotid before the operation was fairly under way. A cure resulted, although the operation of removal was not completed.

Two patients, operated on by Pirogoff, on account of hemorrhage due to ulceration, recovered, and another (a child) died from recurring hemorrhage after it had been carelessly taken out of the reach of surgical aid. Jüngken's patient recovered, and Heine's case of cirsoid aneurism was cured by ligature of the carotid and excision of the mass, the external carotid having previously been tied. Dewar's case was cured. The common carotid artery in all these cases was tied to arrest hemorrhage. G. Burke cured a case by ligature of the external carotid, and direct application of the actual cautery to the tumor.

Both common trunks were tied in nine cases. The operators were Blackman, Gunderloch and Müller, Kuhl, Mussey, Pirogoff, Robert, Rodgers and Van Buren, Ullman, and Warren. The interval between the two operations varied, and is given in the table. Remarkable as it may seem, only two of these patients died. Of the seven who recovered, one was cured (not however until after compression was made over the tumor), and two were improved. Mussey's patient was only improved after the second ligation, but was cured

[1] New York, 1879.

after a bloody excision. The tumor was exceedingly large, and the dilated arteries were tied one by one. More that twenty ligatures were applied, and the hemorrhage is said to have been dangerously profuse.

Other surgeons, besides Mussey,[1] who have practised excision of cirsoid arterial and other "vascular tumors," are Bradley,[1] Busch,[1] Heine,[1] Graefe,[2] Gibson,[2] Buchanan,[3] Sydney Jones,[4] Warren,[1] Weitzer,[2] Guéniot,[2] and Hart.[2] The latter froze the tumor, and cut well into sound tissue; little blood was lost. The late Prof. Spence, of Edinburgh, cured a deep-seated erectile tumor of the hand by galvano-puncture.[5] Nélaton operated in a cirsoid tumor of the forehead in a similar way, and with like success.

Barwell operates upon vascular tumors by what is termed the *scarless method.*[6] Having carefully made out the limits of the tumor, a needle armed with a silver wire is passed under the skin, and subcutaneously around the outskirts of the tumor, to a point opposite the place of entrance. The needle is again introduced at the point from which it has just emerged, and is carried around the remainder of the tumor, and out at the first point of entrance. The base of the tumor is thus looped by a wire which can be tightened beneath the skin at will. Barwell uses a slot of vulcanized rubber which he slides down upon the wire to tighten it around the tumor. If the growth be very large, he advises the needle to be brought out at frequent intervals.

Direct, local compression has been tried by patient and expert surgeons, but has not met with success.

Gosselin[7] in his classical paper reports several successful cases in which he employed hypodermic injections of perchloride of iron into the mass. This idea was original with Broca, who applied the styptic endermically with success. Pitha, of Prague, and Schuh, following Broca, thus cured three cases (Gosselin). Berger[8] reports a case of cirsoid aneurism of the hand treated by this method. Velpeau, Gherini, and Demarquay have performed the same operation. In Demarquay's case, the radial and ulnar arteries had been tied.

The method of procedure is as follows: The tumor must be compressed, so that while the circulation ceases the growth remains full of blood. This condition must be maintained for at least ten minutes after the injection. The syringe being filled, the air is carefully excluded, and the needle is introduced about a quarter of an inch into the mass, when the solution is discharged. Kneading, to disseminate the fluid, is then practised, and the finger is placed upon the hole made by the needle, or the needle and syringe may be left in, during the ten minutes.

Pain is immediately present, and persists for several hours. After an interval of ten or fifteen days, the operation may be repeated, if necessary. Eight or more operations have been required to effect a final cure. Ulceration may follow, but it is usually limited. At times, unhealthy granulations bud up from these ulcerating patches, requiring repeated burning with nitrate of silver or with the actual cautery.

In one of Gosselin's cases, hemorrhage was so frequent and persistent that deligation of the parent vessel—the femoral—was at one time considered, but this was happily avoided by repeated use of the actual cautery.

Gosselin's cases were three in number:—

CASE I.—*Cirsoid Arterial Tumor of the left Leg.*—The patient was a woman, aged 25. At birth she had a small red stain or spot in the skin at the upper and anterior

[1] See the author's Essays in Surgical Anatomy and Surgery. New York, 1879.
[2] Holmes's System of Surgery, 2d ed. vol. iii. p. 540.
[3] British Medical Journal, June, 1875, p. 835.
[4] Lancet, 1882.
[5] Medical Times and Gazette, Aug. 21, 1875, p. 209.
[6] Lancet, May 8, 1875, p. 642.
[7] Archives Gén. de Médecine, tom. ii. 1867, p. 636–659.
[8] Gazette des Hôpitaux, 1882, p. 1082.

part of the left leg, which up to her twelfth year had grown about as large as an almond. At 15 she first noticed that pulsation began in it. After this date it grew more rapidly, projecting, however, very slightly from the surface, until, at the age of 22, it began to ulcerate without any assignable cause. Hemorrhage occurred, which ceased by compression, but not until syncope had ensued. Repeated bleedings occurred up to her twenty-fifth year, when the injections were commenced. From July 12 to August 23, seven injections were made. Ulceration began, and frequent hemorrhages occurred between October 12 and 18, which were arrested by the actual cautery and compression. Cure resulted at the end of eleven months.

CASE II.—*Cirsoid Arterial Tumor of the Forehead with Arterial Varices; Hemorrhage during many years; four Injections of Perchloride of Iron; Cure.*—Patient was a man, aged 39; was born with a red mark on his forehead, which disappeared at his tenth year. About nineteen years later, when in his twenty-ninth year, a tumor was noticed in the same place, about as large as a cherry stone, and two years later he felt it begin to pulsate. After that time it continued to grow, and was the source of frequent hemorrhages without any direct injury or known cause. The patient had controlled the bleeding by compression. At the time of operation, the growth was about two inches in diameter, and projected from the skin about one-third of an inch. February 12, while pressure was made on both primitive carotids, injections were made with two syringes, one needle being introduced on each side of the tumor. The compression of the carotids was continued ten minutes. The tumor still pulsated at points. Compress applied; pain was severe during the day of operation and the next day following. Operation repeated on the 1st of March. March 13, tumor was solid and without pulsation throughout two-thirds of its extent. Two injections made. March 20, tumor began to ulcerate at two limited points, which were soon filled with exuberant granulations. These resisted alcoholic dressings and the application of nitrate of silver. March 24, pulsation re-appeared at one point, and the injection was repeated. May 20, the granulations persisting, actual cautery was applied. Same on June 6. July 8, patient discharged, cured.

CASE III. does not differ materially from the two preceding cases, either as to its clinical history or as to its treatment.

The results of this method of treating vascular tumors are gratifying, and the operation is worthy of repetition. In growths of small size, I should prefer to try the method of Barwell, and, if this failed, then the injection of perchloride of iron or other coagulating solution. The success achieved by Spence and Nélaton with galvano-puncture was such as to justify further trial of this method.

Cases of spontaneous cure of vascular tumors are reported. Dr. Krackowizer presented to the New York Pathological Society a patient in whom pulsation had entirely ceased in a cirsoid tumor which was contracted, solid, and shrivelled at various points; the peculiar rustling noise, also, of which the patient had complained, was now entirely absent when he was quiet. The man was forty-five years of age; the tumor was congenital, and had grown to a considerable size, but without pain or hemorrhage. Dr. Krackowizer referred to two other cases recorded by Orfila and Chevalier.

TABLE OF CASES IN WHICH THE COMMON CAROTID ARTERY HAS BEEN TIED ON ACCOUNT OF ANEURISM BY ANASTOMOSIS AND ARTERIAL VARIX. (NOT INCLUDING ANASTOMOTIC OR PULSATING TUMORS OF THE CAVITY OF THE ORBIT.)

| No. | Name of operator. | PATIENT. Sex. | Age. | Side. | Nature of disease. | Duration of disease. | Date of operation. | Hemorrhage occurred after operation. | Lig. came away No. days after operation. | RESULT. As to life. | Local condition. | Cause of death, date after oper'n. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Arendt, 1821 | M. | 35 | R. | Aneurism anast. of face. | ........ | Nov. 18, 1821 | 6 weeks. | 17 | Recovered. | Cured. | ............ | The secondary hemorrhage lasted for several days, but was slight; 12 ligatures were applied during the operation. |
| 2 | Auchinloss, 1839. | ... | 23 | L. | Aneurism anast. of head. | 23 years. | 1839 | ........ | 20 | Recovered. | Cured. | ............ | Pulsation in tumor ceased immediately; cure rapid. |
| 3 | Aubert, Moscow. | F. | y'g | R. | Aneurism anast. of ear. | ........ | .......... | Some days. | ........ | Died. | .......... | Inflammation brain. | Tumor began to decline; pain in head; hemiplegia; death. |
| 4 | Bernhard, 1833. | F. | 39 | R. | Aneurism anast. near car. | 8 years. | Mar. 26, 1833 | ........ | ........ | Recovered. | Cured. | ............ | No cerebral symptoms. |
| 5 | Bertherand, 1860. | F. | 4½ mos. | L. | Erectile tumor of temporal region. | 4½ mos. | .......... | ........ | ........ | Recovered. | Cured. | ............ | External carotid tied first; as tumor was not affected, common carotid was tied and first ligature removed. No cerebral symptoms followed. |
| 6 | Busch, 1819. | M. | 34 | L. | Aneurism anast. of head and face. | ........ | May 10, 1819 | ........ | 12 | Recovered. | Improved. | | |
| 7 | Bushe, 1830. | M. | 19 | L. | Erectile tumor of cheek. | 19 years. | Jan. 15, 1830 | ........ | 29 | Recovered. | Cured. | | |
| 8 | Blackman, 1843. | M. | 30 | R. | Fungous tumor of neck. | 2 years. | Jan. 21, 1843 | ........ | ........ | Died. | .......... | 8th day (exhaust.) | |
| 9 | Blackman, 1848. | M. | 15 | R. | Fungus hæmatod. | do. | 1848 3 weeks after, 2d operat'n. | ........ | 13 | Recovered. | | | |
| 10 | Blackman, 1848 | M. | 15 | L. | do. do. | do. | 1848 | ........ | 14 | Recovered. | (Uncertain). | | Same case as No. 9. |
| 11 | Chelius, 1836. | M. | 19 | R. | Aneur. varix. of temporal region. | 1 year. | Jan. 18, 1836 | ........ | 21 | Recovered. | Cured. | | |
| 12 | Cherry, 1858. | F. | 12 | ... | Erectile tumor. | ........ | .......... | ........ | ........ | Recovered. | Cured. | | |
| 13 | Deguisé, 1827. | F. | ...... | ... | Erectile tumor. | ........ | .......... | ........ | ........ | Died. | | | |
| 14 | Dewar, 1860. | F. | 27 | R. | Hem.; pulsating tumor of tonsil. | ........ | June 2, 1859 | ........ | 14 | Recovered. | Cured. | ............ | Syphilitic diathesis. |
| 15 | Detmold, Prof. Wm., 1840. | F. | 26 | R. | Vascular tumor of right side head. | ........ | 1840 | ........ | 16 | Recovered. | No improvem't | ............ | Operation made no impression on tumor; died 18 months afterwards of phthisis. |

CASES IN WHICH THE COMMON CAROTID ARTERY HAS BEEN TIED.—*Continued.*

| No. | Name of operator. | PATIENT. Sex. | Age. | Side. | Nature of disease. | Duration of disease. | Date of operation. | Hemorrhage occurred after operation. | Lig. came away No. days after operation. | RESULT. As to life. | Local condition. | Cause of death, date after oper'n. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 16 | Detmold, 1842. | M. | ...... | L. | Vascular tumor of chin. | ........ | 1842 | ........ | 10 | Recovered. | Cured. | ............. | After ligature, tumor laid open and hot iron applied. |
| 17 | Detmold, 1845. | ... | 8 mos. | L. | Aneurism anast. of left ear. | ........ | 1845 | ........ | 10 | Recovered. | Cured. | | |
| 18 | Dupuytren, | M. | 20 | R. | Erectile tumor of ear and temple. | ........ | April 8, 1818 | ........ | 12 | Recovered. | | | |
| 19 | Gunderlach, 1831. | ... | $5\frac{1}{2}$ | R. | Aneurism anast. of frontal and nasal regions. | $5\frac{1}{2}$ years. | Sept. 13, 1831 | ........ | 13 | Recovered. | Not cured. | | Same case as No. 20. |
| 20 | Möller, 1832. | ... | ...... | L. | do. | $5\frac{3}{4}$ years. | Jan 18, 1832 | ........ | 28 | Recovered. | ? | ............. | Patient died subsequently of variola. |
| 21 | Grandchamp, 1839. | F. | 50 | R. | Pulsating tumor of face. | 2 years. | 1839 | ........ | ........ | Recovered. | ........... | ............. | During previous year, the two facials, the transverse facial, infra-orbital, and temporal artery of the affected side were tied, with no effect upon tumor. No cerebral symptoms followed ligature of common trunk. |
| 22 | F. H. Hamilton, 1860. | M. | 2 | R. | Erectile tumor of outer angle of right eye. | 6 weeks. | Feb. 12, 1860 | ........ | ........ | Recovered. | No benefit. | ............. | Tumor covered right temple, had pushed eye out and destroyed it; soft, elastic, with distinct bruit; tumor returned subsequently, and patient died from it. |
| 23 | Hart, 1861. | M. | 11 | L. | Aneurism anast. of upper lid and orbit. | ........ | 1861? | ........ | 8 | Recovered. | Cured. | ............. | No symptoms of cerebral disturbance. |
| 24 | Heine, 1869. | M. | 21 | ... | Hem'ge; removed cirsoid aneurism of ear and scalp. | 5 days. | 1869 | ........ | ........ | Recovered. | Cured. | ............. | External carotid tied when tumor was removed; five days after, hemorrhage and ligature of common carotid. |
| 25 | Jobert, 1836. | M. | ...... | R. | Erectile tumor in temporal region. | 4 mos. | Aug. 22, 1836 | ........ | ........ | Died. | ........... | Second day. | No cerebral symptoms. |
| 26 | Jüngken. | M. | 19 | R. | Hem., aneurism by anastomosis. | ........ | ........... | ........ | 16 | Recovered. | Not cured. | | |
| 27 | Kerr, 1840. | F. | 67 | R. | Vascular tumor; supposed aneur. | ........ | April 30, 1840 | ........ | 26 | Recovered. | ........... | ............. | Patient died 9 months after operation from pneumonia. |
| 28 | Kuhl, 1843. | M. | 53 | L. | Aneurism anast. occip. traum. | 24 years. | May 24, 1843 | Sev. times. | 27 | Recovered. | Not cured. | ............. | One year after a fall from a horse on occiput; hemorrhage 72 days after first operation. |
| 29 | Kuhl, 1843. | M. | 53 | R. | do. | do. | Aug. 4, 1843 | 3d day. | 27 | Recovered. | Cured. | ............. | The second carotid tied; no marked cerebral symptoms followed the second operation, although convulsions occurred after the first. |

CASES IN WHICH THE COMMON CAROTID ARTERY HAS BEEN TIED.—*Continued.*

| No. | Name of operator. | PATIENT. Sex. | PATIENT. Age. | PATIENT. Side. | Nature of disease. | Duration of disease. | Date of operation. | Hemorrhage occurred after operation. | Lig. came away No. days after operation. | RESULT. As to life. | RESULT. Local condition. | RESULT. Cause of death, date after oper'n. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30 | Kuhl, 1836. | F. | 43 | R. | Vascular tumor of frontal region. | 4 mos. | Sept. 16, 1836 | ........ | ........ | Died. | .......... | Second day. | Cerebral symptoms followed; unconscious four hours. Autopsy: Tuberculosis of lungs; pneumogastric nerve injured by inflammation of surrounding structures; right subclavian included in ligature by mistake. |
| 31 | Lenoir, 1851. | F. | y'g | ... | Erectile tumor of temporal region. | ........ | .......... | ........ | 15 | Died. | | | |
| 32 | Lisfranc, 1827. | F. | 18 | R. | Fungus hæmatod. (supposed aneurism). | ........ | .......... | After. | ........ | Died. | .......... | 8th day. Hemorrhage. | Fungus of left cerebral fossa; petrous portion temporal bone carious; internal jugular vein obliterated. |
| 33 | Liston, 1841. | M. | 20 | L. | Vascular tumor of neck. | ........ | .......... | After. | ........ | Died. | .......... | 10th day. Hemorr'ge. | |
| 34 | Lücke, 1866. | M. | 66 | L. | Spontaneous pulsating tumor of forehead. | 7 years. | Aug. 9, 1866 | 14, 16, 17th day. | ........ | Died. | .......... | 19th day. Hemorr'ge, delirium. | Delirious after operation. Autopsy: Ulcerated hole in carotid at ligature. |
| 35 | Maisonneuve. | F. | 30 | R. | Varicose aneurism of parietal reg., traumatic. | 2 mos. | .......... | ........ | ........ | Died. | .......... | Third day. | External carotid was tied first; this lig. fell 16th day. The sup. thyroid was tied at this time. Hemorrhage again occurring, the internal and common carotids were tied, followed by complete left hemiplegia. Autopsy: Right hemisphere softened, the sympathetic nerve included in both the internal and common carotid ligatures (*Pilz*). |
| 36 | Maunoir. | M. | 30 | L. | Cirsoid aneurism. | ........ | Before 1821 | ........ | ........ | Recovered. | No improvem't | | |
| 37 | Mayo, 1833. | M. | 5 mos. | L. | Erectile tumor of face. | 5 mos. | 1833 | ........ | 8 | Recovered. | Improved. | | |
| 38 | McClellan, 1825. | F. | 9 | L. | Erectile tumor of cheek. | ........ | 1825 | ........ | 14 | Recovered. | Cured. | | |
| 39 | McClellan, 1829. | M. | 43 | L. | Aneurism anast.; antrum of nose. | Several years. | May 12, 1829 | ........ | ........ | Died. | .......... | 12 days. Cerebral complications. | Paralysis (right) 24 hours after operation; 8th day coma; death in convulsions. |
| 40 | Michels, 1835. | F. | 23 | L. | Aneurism anast. of face and occiput. | 2 years. | Mar. 12, 1835 | ........ | 30 | Recovered. | Cured. | ............ | Patient was 3 months pregnant at time of operation; did well. |
| 41 | Millies. | ... | ...... | ... | Aneurism, fusiform; superior thyroid. | ........ | .......... | ........ | ........ | Died. | .......... | Four days. | Died suddenly; no autopsy. |

CASES IN WHICH THE COMMON CAROTID ARTERY HAS BEEN TIED.—*Continued.*

| No. | Name of operator. | Patient. Sex. | Age. | Side. | Nature of disease. | Duration of disease. | Date of operation. | Hemorrhage occurred after operation. | Lig. came away No. days after operation. | Result. As to life. | Local condition. | Cause of death, date after oper'n. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 42 | Mussey, 1827, New Hampshire. | M. | 20 | R. | Erectile tumor of scalp. | ........ | Sept. 20, 1827 | ........ | ........ | Recovered. | Not improved. | ............. | Tumor afterwards removed, patient lost 2 quarts blood, and more than 20 ligatures were required |
| 43 | Mussey. | M. | 20 | L. | do. | ........ | Nov. 2, 1827 | ........ | ........ | Recovered. | Improved. | | Same case as No. 42. |
| 44 | Mott, Prof. Valentine, New York. | ... | C'd | ... | Aneurism anast. of orbit and nose. | ........ | .......... | ........ | ........ | Recovered. | .......... | ............. | Tumor had crossed bridge of nose and invaded portion of opposite eye. |
| 45 | Mott. | ... | 3 mos. | ... | Aneurism anast. of neck and jaw. | ........ | .......... | ........ | ........ | Recovered. | | | |
| 46 | Mott, 1830. | ... | C'd | ... | Aneurism anast. of temple. | ........ | 1830 | ........ | 15 | Recovered. | Improved. | | |
| 47 | Mott, Prof. A. B., 1854. | F. | $6\frac{1}{2}$ mos. | L. | Aneurism anast. of left side of face. | ........ | Feb. 1, 1854 | ........ | 17 | Recovered. | Cured. | | |
| 48 | Mott, A. B. | F. | 7 y'rs | R. | Fungus hæmatod. at orbit. | ........ | April 10, 1854 | ........ | ........ | Recovered. | Cured. | ............. | Eye was extirpated at same time; no return after two years. |
| 49 | Mott, A. B., 1856. | F. | 23 | L. | Aneurism anast. | ........ | Oct. 30, 1856 | ........ | 21 | Recovered. | Cured. | | |
| 50 | Mott, A. B., 1859. | F. | 9 mos. | R. | Large aneurism anast. over parotid gland. | ........ | Jan. 20, 1859 | ........ | 14 | Recovered. | Cured. | | |
| 51 | Willard Parker, 1857. | F. | $4\frac{3}{4}$ y'rs | L. | Erectile tumor of face. | $4\frac{3}{4}$ years. | April 6, 1857 | 18th day. | 21 | Recovered. | ? | ............. | Hemorrhage on 18th day controlled by moderate pressure. |
| 52 | Parker, 1861. | F. | 10 mos. | R. | Extensive vascular tumor of face. | 10 mos. | April 29, 1861 | None. | 12 | Recovered. | Cured. | ............. | Three years after operation, patient was perfectly well. |
| 53 | Pirogoff, 1843. | M. | 20 | L. | Hem.; aneurism anastomosis of occipital and temporal region. | ........ | Jan. 16, 1843 | ........ | 5 | Recovered. | Improved. | ............. | At six years of age, small tumor of scalp. In 1843, attempt to remove it resulted in such alarming hemorrhage, that Pirogoff tied carotid. Tumor not entirely disappearing by following year, remaining carotid tied. Tumor was then treated by compress, and cured. |
| 54 | Pirogoff, 1844. | M. | 20 | R. | do. | ........ | Jan. 9, 1844 | ........ | 16 | Recovered. | Cured ? | | Same case as No. 53. |
| 55 | Pirogoff, 1837. | ... | 9 mos. | L. | Erectile tumor, occiput. | 9 mos. | Jan. 26, 1837 | Occurred. | ........ | ........ | .......... | 117th day. Hemor'ge. | |
| 56 | Pirogoff. | M. | Mid. age. | L. | Hem.; aneurism anast. | ........ | .......... | ........ | ........ | Recovered. | ? | | |

## Cases in which the Common Carotid Artery has been tied.—*Continued.*

| No. | Name of operator. | Patient. Sex. | Age. | Side. | Nature of disease. | Duration of disease. | Date of operation. | Hemorrhage occurred after operation. | Lig. came away No. days after operation. | Result. As to life. | Local condition. | Cause of death, date after oper'n. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 57 | Pirogoff. | ... | C'd | L. | Hem.; aneurism anast. | ........ | ........ | After. | ........ | Died. | ........ | Hemorr'ge | Child was doing well; mother removed beyond reach of surgical interference when hemorrhage occurred, causing death. |
| 58 | Post, Prof. A. C., N. Y., 1845. | M. | 27 | R. | Telangectasis right cheek. | Many years. | April, 1, 1845 | ........ | ........ | Died. | ........ | Phlebitis; pyæmia; delirium. | Autopsy: Two phlebolithes were found in tumor. Phlebitis of int. jugular, although vein was not wounded in the operation; pus in vein. |
| 59 | Randolph, 1833. | M. | 25 | R. | Aneurism varix. | ........ | 1836 | ........ | ........ | Died. | ........ | Next day. Cerebral complications. | Coma soon after operation. |
| 60 | Robert, 1846. | F. | 19 | L. | Aneurism, cirsoid, frontal region. | 19 years. | June 5, 1846 | ........ | 19 | Recovered. | ........ | ........ | Slight cerebral symptoms followed each operation, but passed away. |
| 61 | Robert, 1847. | F. | 19 | R. | do. | 19½ years. | Feb. 22, 1847 | ........ | 18 | Recovered. | Marked benefit. | ........ | In May, 1850, there was no pulsation in the tumor. Same case as No. 60. |
| 62 | Robert, 1857. | M. | ...... | L. | Aneurism, cirsoid. | ........ | 1857 | ........ | ........ | Died. | ........ | A few days | |
| 63 | Rodgers, J.K., 1844 | F. | 11 | R. | Aneur. by anast., head. | ........ | 1844 | ........ | ........ | Recovered. | Not cured. | ........ | Temporal artery was also tied. (See No. 70.) |
| 64 | Rogers, D. L., 1832. | ... | 8 mos. | R. | Erectile tumor of face. | 8 mos. | Dec. 12, 1832 | ........ | ........ | Recovered. | Cured. | | |
| 65 | Southam, 1864. | F. | 28 | R. | Aneur. by anast. head. | 8 years. | May 20, 1864 | ........ | 14 | Recovered. | Cured. | ........ | No anæsthetic; ulcerated, and hemorrhage before operation. |
| 66 | Thebaud, J.S. 1865. | ... | 6 mos. | ... | Aneurism anast. of face and eye. | ........ | ........ | ........ | 10 | Recovered. | Not cur'd but benefited | | |
| 67 | Unknown, 1823. | M. | 19 | L. | Erectile tumor in region of left ear. | ........ | 1823 | ........ | ........ | Recovered. | Not cured. | | Same case as No. 68. |
| 68 | Ullman, 1824. | M. | 20 | R. | do. | ........ | 1824 | Twice. | ........ | Died. | ........ | 3d day. Exhaust'n | On account of hemorrhage, a second ligature had to be applied lower down. |
| 69 | Unknown, Hotel Dieu. | M. | 20 | ... | Cirsoid aneurism of scalp. | ........ | ........ | ........ | ........ | Recovered. | Improved. | ........ | Temporal articular, and occipital tied at same time. |
| 70 | Van Buren, 1850. | F. | 17 | L. | do. | ........ | 1850 | ........ | 14 | Recovered. | Not cured. | ........ | Disease latent; right carotid had been tied six years previously by Dr. J. K. Rodgers. No cerebral symptoms followed. (See No. 63.) |
| 71 | Velpeau, 1835. | M. | 16 | L. | Erectile tumor of temporal region. | ........ | 1835 | Often. | ........ | Died. | ........ | 16th day. Hemorr'ge. | Internal carotid was also tied. |

CASES IN WHICH THE COMMON CAROTID ARTERY HAS BEEN TIED.—*Continued.*

| No. | Name of operator. | Patient. Sex. | Age. | Side. | Nature of disease. | Duration of disease. | Date of operation. | Hemorrhage occurred after operation. | Lig. came away No. days after operation. | Result. As to life. | Local condition. | Cause of death, date after oper'n. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 72 | Warren, 1845. | M. | 23 | L. | Erectile tumor of face and neck. | ........ | Oct. 5, 1845 | ........ | ........ | Recovered. | No better. | .............. | Tumor diminished about one-half after first ligature, but there was no positive improvement. |
| 73 | Warren, 1845. | M. | 23 | R. | Erectile tumor of face and neck. | ........ | Nov.9, 1845 | ........ | ........ | Recovered. | Improved. | .............. | Tum. afterward treated by removing a portion and plunging needles into remaining parts. Cured. |
| 74 | Wardrop, 1818. | ... | 6 w'ks | L. | Erectile tumor of cheek. | 6 weeks. | 1818 | ........ | ........ | Died. | ........... | 14th day. Exhaust'n | Tumor ulcerated freely after operation. |
| 75 | Wardrop, 1826. | F. | 5 mos. | L. | Erectile tumor of face. | ........ | March, 1826 | ........ | 11 | Recovered. | Cured. | | |
| 76 | Wardrop, 1827. | M. | 22 | L. | Erectile tumor of face and head. | 12 years. | Oct.(?) 1827 | ........ | 25 | Recovered. | Improved. | .............. | Died 103 days after operation; psoas abscess. |
| 77 | Wardrop, 1842. | M. | 6 mos. | R. | Aneurism anast. of cheek. | 6 mos. | Mar. 2, 1842 | ........ | 9 | Recovered. | Not cured. | .............. | Three years after operation, but little change in tumor. |
| 78 | Woodward, A. T., 1860. | F. | 6 mos. | L. | Aneurism anast. of left external carotid. | Some time. | ........... | ........ | ........ | Died. | ........... | 4th day. | |
| 79 | Wutzer, 1847. | M. | 25 | ... | Aneurism anast. external carotid. | ........ | ........... | ........ | 18 | Recovered. | Cured. | .............. | On account of numerous branches going into tumor, deemed impracticable to tie ext. carotid. |
| 80 | Zeiss. | ... | 15 mos. | L. | Erectile tumor of face. | 15 mos. | ........... | ........ | 8 | Died. | ........... | 114 days. Cere. com. | |
| 81 | Paul, John, 1830. | F. | 28 | R. | Pulsating tumor above ear. | ........ | July 29, 1830 | ........ | 15 | Recovered. | Cured. | | |
| 82 | Bradley, E., New York, 1877. | M. | 20 | L. | Hemorrhage during removal of vascular tumor of parotid and submaxillary regions (Angeioma). | 19½ years. | Dec. 6, 1877 | None. | 3d week. | Recovered. | Cured. | .............. | Tumor grew rapidly within the last year. In operation for removal, while dissecting with the handle of the scalpel, the tumor gave way, and a frightful hemorrhage occurred. The common carotid was tied immediately above the clavicle, the incision being made behind the posterior border of the mastoid muscle. Hemorrhage ceased instantly. The recovery was prompt, and the tumor has entirely disappeared. After ligature of the common trunk the tumor was not removed, but the wound was packed with lint soaked in Monsel's solution. No symptoms of cerebral disturbance. |

The *internal carotid* has never been tied for any of the lesions given in the preceding Table, except in the cases reported by Maisonneuve and Velpeau.

TABLE OF CASES IN WHICH THE EXTERNAL CAROTID ARTERY HAS BEEN TIED ON ACCOUNT OF THE LESIONS MENTIONED IN THE PRECEDING TABLE.

| No. | Name of operator. | Patient. Sex. | Age. | Side. | Nature of disease. | Duration of disease. | Date of operation. | Hemorrhage occurred after operation. | Lig. came away No. days after operation. | Result. As to life. | Local condition. | Cause of death, date after oper'n. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Bertherand, 1860. | F. | 4½ mos. | L. | Erectile tumor of temporal region. | ........ | ........... | ........ | ........ | Recovered. | Cured. | .............. | External carotid first tied some hours before common. As the effect on the tumor was not marked, this last vessel was tied and the ligature removed from the external. (As the ligature was tightened and remained several hours *in situ*, it is probable that the vessel was obliterated by the operation, the inner coat being cut and turned in as is the rule in such cases. —*Author.*) |
| 2 | Busch, W., 1872. | F. | 29 | R. | Pulsating vascular tumor back of head. | 24 years. | Aug. 25, 1872 | ........ | 15 | Recovered. | ........... | .............. | Patient writes Dec. 20, 1873: "Am not able to work; appetite good; sleep badly; pulsation in tumor; place is not so well as when I was discharged." Hemorrhage from the sloughing tumor some time after oper., only very slight. |
| 3 | do. | F. | 29 | L. | .................. | ........ | do. | ........ | 16 | Recovered. | Not cured. | | Same case as No. 2. |
| 4 | Bushe, G., 1827. | F. | 2½ | R. | Hem. after removing pulsating tumor temporal region. | ........ | 1827 | None. | 13–18 | Recovered. | Cured. | .............. | Pressure and hot iron had been tried to arrest hemorrhage before ligature. No hemorrhage after operation. |
| 5 | V. Bruns, 1856. | M. | 25 | R. | Vascular tumor left cheek, lip, and nose. | ........ | 1856 | ........ | 20 | Recovered. | | | |
| 6 | do. | ... | ...... | L. | do. | ........ | ........... | ........ | 10 | Recovered. | No benefit. | | Same case as No. 5. |
| 7 | Heine, C., 1869. | M. | 21 | ... | Hem. cirsoid tum. scalp and ear. | ........ | ........... | Severe | ........ | Recovered. | Cured. | .............. | Five days after ligature of external carotid, on account of hemorrhage, the common carotid was tied. Hemorrhage from seat of ligature. |
| 8 | Maisonneuve 1849. | F. | 30 | R. | Aneurism anast. temporal region. | 2 mos. | ........... | After. | 16 | Died. | ........... | Coma; not on account ligature external carotid. | 21 days after ligature of external carotid, hemorrhage; 26th and 27th, hemorrhage, then ligature of common and internal carotid; sympathetic nerve included in last ligature. Hemiplegia ensued after ligature of common trunk. |

CASES IN WHICH THE EXTERNAL CAROTID ARTERY HAS BEEN TIED.—*Concluded.*

| No. | Name of operator. | PATIENT. Sex. | Age. | Side. | Nature of disease. | Duration of disease. | Date of operation. | Hemorrhage occurred after operation. | Lig. came away No. days after operation. | RESULT. As to life. | Local condition. | Cause of death, date after oper'n. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 9 | Mastermann, | F. | 16 | R. | Aneurism anast. ear. | ........ | ........... | ........ | 5 | Recovered. | Cured. | ............. | Part of tumor ligatured also, and part cut away and nitrate of silver applied. |
| 10 | McBurney, New York, 1882. | M. | 12 | L. | Cirsoid of auricle of ear. | ........ | ........... | ........ | ........ | Recovered. | .......... | ............. | Pulsation ceased after operation, but tumor did not decrease much in size; 3 months after operation, patient much improved. |
| 11 | Roser, 1856. | F. | ...... | R. | Varicose aneur. of left ear. | ........ | 1856 | ........ | ........ | Recovered. | Cured. | ............. | Several smaller vessels tied at same time. |
| 12 | Sédillot. | ... | ...... | ... | Vascular growth of head and face. | ........ | ........... | None. | ........ | Recovered. | .......... | ............. | Two ligatures; artery divided between them. |
| 13 | Wallace, 1833. | F. | 13 | R. | Nævus of right cheek. | ........ | ........... | None. | 15 | Recovered. | Improved. | | |
| 14 | Wutzer, 1841. | M. | 41 | L. | Fungus of palate. | ........ | ........... | Once. | 19–22 | Recovered. | .......... | ............. | Hemorrhage after operation from the occipitalis. |
| 15 | Wutzer, 1847. | M. | 38 | R. | Fungus of neck and fauces. | ........ | ........... | ........ | 16 | Recovered. | | | |

In the preceding table are collected 73 cases, in which—either as a means of cure or to prevent hemorrhage before or after removal of *aneurism by anastomosis*, *vascular* or *erectile tumor*, *fungus* or *fungus hæmatodes*, or cirsoid *aneurism* — the ligature was applied to the *common carotid artery*. The number of arteries tied was 82, both being operated upon in 9 patients. This does not include 60 additional cases in which this artery was tied for pulsating tumor of the orbit.[1] Taking these cases as one group — as vascular growths—it will be seen that of the total of 73, death resulted in 21 instances. Of the 51 patients who recovered, 27 are noted as cured, 10 as improved, 5 as not improved, while 9 are noted as recovered, but either not cured, or with the result, otherwise than as regards life, not mentioned.

If these cases are subdivided into three classes, taking those reported as *aneurism by anastomosis*, *vascular growth*, and *erectile tumor* as one class, *fungus hæmatodes* as another, and *arterial varix* as a third, we shall be better able to arrive at a safe conclusion as to the relative merits of this operation in the several groups of cases.

In 59 patients the common carotid was tied on account of *aneurism by anastomosis* and *vascular* or *erectile tumor*. Death resulted in 16 instances. In one of these fatal cases the operation was performed to arrest hemorrhage, and in another both carotids were tied. Of the 43 recoveries, 24 were reported as cures. In two of these cases the cure was not effected until both the common trunks had been tied. One tumor was laid open after the artery had been tied, and the actual cautery applied. In another case the artery was tied during the extirpation of the tumor. Seven patients recovered, and were noted as "improved," and in the cases of two of these, both common carotids were tied. Three of the patients who recovered are noted as "not improved," and nine as "recovered," with no other information as to the result, with the exception of two, who were "not cured." In one of the cases noted as a recovery, the operation was required to arrest hemorrhage, and two others were cases of double ligature of the carotids.

For *fungoid vascular growths* 4 cases are given: 2 patients died; 1 was "cured," after the orbit and surrounding structures had been removed and the wound cauterized; and in one case of double ligature it is merely noted that the patient "recovered."

Ten cases of *arterial varix* are reported, with 2 "cures," 3 "recoveries with improvement" (one a case of double ligature), and one "recovery without improvement." In one case which was cured, the varix was extirpated, and in one, which proved fatal, Maisonneuve had previously tied the external carotid without favorable result.

The results in the foregoing cases are not sufficiently encouraging to justify the ligature of the common carotid for these lesions. Exceptional cases will, however, occur, in which pressure and other means fail, which may demand even this dangerous procedure.

Of the 13 instances in which the *external carotid* was tied for the lesions heretofore mentioned (the artery of the two sides being ligated in two cases), none proved fatal excepting the operation of Maisonneuve, in which the common carotid was also tied (the sympathetic nerve being included in the ligature by accident).

The external carotid alone was tied in 10 patients (the double operation being performed in two instances). All recovered. Busch tied the two trunks: the patient recovered, but was not cured. Von Bruns did the same operation, and met with a like result.

[1] See author's Essays in Surgical Anatomy and Surgery, p. 127. New York, 1879.

G. Bushe removed a pulsating growth, and tied the external carotid to arrest the hemorrhage. The patient recovered and was cured.

Mastermann tied the artery, ligated a portion of the tumor, and cauterized the remainder with nitrate of silver, with a cure.

Roser tied the artery and a cure resulted. Sédillot's patient "recovered." Wallace's was "improved." Wutzer's two cases "recovered," and McBurney's has been much improved, with a great probability of a permanent cure.

Angeiomata.—The three next varieties of "vascular tumor," which may be grouped together under the name of *Angeiomata*, are: (1) the *Arterial Cutaneous Tumor*, or *Aneurism by Anastomosis*, composed of dilatations or elongations of the arterioles, either normal or new-formed, in the skin; (2) the *Capillary Cutaneous Tumor*, consisting of dilatations and elongations of the normal or new-formed capillaries of the skin; and (3) the *Venous Cutaneous Tumor* (*Cavernous Nævus*, or simply *Nævus*), composed of dilatations of the normal or new-formed venous radicles of the skin.

The angeiomata are considered by some writers as strictly new-formations of bloodvessels. There is little doubt, however, that many vascular tumors are chiefly made up of normal vessels which have undergone dilatation or hypertrophy. Other names that have been given to angeiomata are congenital nævus, erectile tumor, telangiectasis or plexiform angeioma, aneurism by anastomosis, ecchymoma, cavernous nævus, and fungus hæmatodes. According to Depaul, one-third of the children born in one of the eleemosynary institutions at Paris, had congenital nævi, the greater number of which disappeared spontaneously during the first few months of life. They occur chiefly in the skin, and are especially apt to appear on the forehead, face, ears, and neck.

*Structure and Symptoms.*—Angeiomata commonly form flattened, slightly projecting tumors, varying in size from a mere speck to as much as an inch in diameter, and are composed of new-formed, dilated, freely anastomosing capillaries, arterioles, and veins, in irregular, labyrinthine masses. They vary in color, being at times grayish-blue or red. Often the only indication of their presence is the appearance of a diffuse redness over a considerable surface. Examined microscopically, the walls of the vessels are crowded with cells, and the vessels are imbedded in a network of fibrous and adipose tissue. The superficial and deep cutaneous vessels—including the vessels of the hair follicles, sweat glands, and adipose tissue—join in the formation of these tumors. The disease may extend into the muscles and deeper tissues.

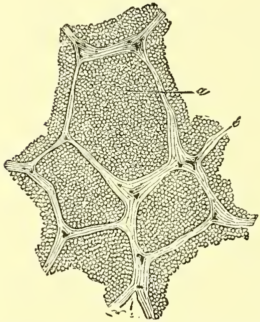
The majority of angeiomata are soft and yielding, and can be emptied by pressure; but when of great vascularity and long standing, when there has been an extensive proliferation of the perivascular connective tissue, pressure will not cause their disappearance. Some are very painful, and others entirely free from sensibility.

Venous cutaneous tumors are composed, in great part, of new-formed, erectile tissue, analogous to that found in the corpora cavernosa. The structure is white and dense, the caverns communicating freely with each other. These at times are found to contain the chalky concretions which have been considered on a previous page as *phlebolites*. The circulation is active in these tumors, and their volume variable.

The walls of the sinuses contain a dense, fibrous stroma, involuntary muscular tissue, and striated muscular fibres when the tumor is encroaching on the muscles. They are lined by the same endothelium as the normal veins. In specimens removed and immediately immersed in alcohol, which causes instant coagulation of the blood in the sinuses, it is found that the blood pre-

sents the same appearances as the normal blood, but that the white corpuscles are less numerous. They do not adhere to the walls of the vessels. This is considered as proof of a rapid circulation, since in veins where the circulation is weakened or retarded, the leucocytes tend to adhere to the walls. After excision the vessels contract, forcing out their contents, and the mass shrinks to a comparatively small size.

Fig. 530.




Cavernous angeioma of the liver. Section made after the tumor had been immediately submerged in alcohol: *a*, cavernous spaces filled with blood-corpuscles; *b*, fibrous walls of the sinuses. Magnified 150 diameters. (From Cornil and Ranvier.)

These tumors are not all erectile, and some which have been erectile for a time lose this property. Gross describes a form of nævoid tumor as *nævoid elephantiasis*, consisting of a hypertrophied condition of the skin and subcutaneous connective tissue. The affection, which is either congenital or comes on soon after birth, is found usually in the lower extremities, though it may occur elsewhere.

The theories as to the origin of these neoplasms are various. Some hold that simple dilatation of contiguous veins occurs, when, the sacculated vessels coming in contact, the walls are absorbed, and thus many cavities which formerly were separate, form one or more large, multilocular, cavernous tumors. These dilatations occur not only in the skin and subcutaneous tissues, but also in bone and muscle. No tissue can be considered exempt. Rokitansky holds that they originate in the areolar tissue, from embryonic, new-formation tissue, and that the vascularization of this new tissue is one of the last processes of its development. He compares the alveoli of the cavernous angeioma to those of carcinoma.

Rindfleisch believes that the appearance of these tumors is preceded by a proliferation of embryonic material in the intervascular spaces, and that this material, undergoing the usual process of cicatrization and contraction, causes a shrinkage in the intervascular areas, when the vessels dilate to occupy the space left vacant by the contracting tissues (Billroth).

Cornil and Ranvier say that in the active development of angeiomata there is a proliferation of embryonic tissue, rich in new-formed vessels, which, increasing rapidly in size, come in contact and communicate with each other by absorption of contiguous surfaces.

Angeiomata may develop in fatty and other neoplasms. Billroth mentions a case in which a large cavernous angeioma was found in a lipoma removed from the scapular region. They have been known to originate as a result of injury. Gross cites a case, reported by Dr. J. Mason Warren, of a man thirty-six years old, who had a large aneurism by anastomosis, situated on the lobe of the ear, which resulted from a frost-bite which the patient had suffered in his sixteenth year. In addition to the tissues already mentioned in which angeiomata are developed, may be mentioned the spleen, kidney, liver, and lung. The liver is frequently, the lung very rarely, involved. In bones, this disease exhibits the same erectile characters as in other structures. It occurs in the flat bones by preference, especially those of the cranium, jaws, and scapula, being often very painful, and grave as to prognosis. Angeiomata are not infrequently situated on the labia of women. Holmes Coote has observed serous cysts in connection with these vascular growths. An explanation of their formation is, that communication of a portion of one dilated

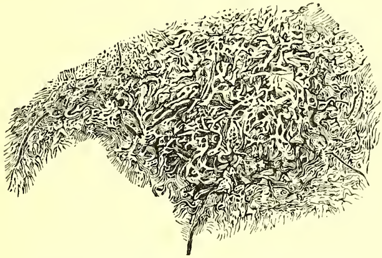
PLATE XVI.

Rapidly growing Naevus involving both skin and deeper tissues.
(From a patient at the Children's Hospital, Philadelphia.)

vessel with other vessels is cut off, and that the corpuscles and coloring matter of the blood disappear, the serum remaining as a cystic fluid.

The question of the relation of these tumors to carcinomata and sarcomata is worthy of consideration. J. Müller has reported a malignant (recurrent)

Fig. 531.



Aneurism by anastomosis in parietal bone. (Erichsen.)

angeioma. A case of melanotic degeneration of a congenital nævus in a woman aged forty has been reported by Dr. Stiles. The vascular dilatations in osteo-sarcomata and in other forms of carcinoma and sarcoma are analogous to those found in cavernous angeiomata. Some of the malignant tumors pulsate like the angeiomata. An angeioma may be diffuse or encapsulated.

The *prognosis* depends upon the size and location of the neoplasm.

The *diagnosis* is not difficult in the superficial tumors, but in those deeply situated, and in the track of large vessels, the differentiation from aneurism is not easy.

The arterial and capillary cutaneous tumors are almost always congenital; the venous tumors are rarely so. Angeiomata may be distinguished from osteo-sarcomata which have perceptible pulsation, by the crackling impression conveyed to the sense of touch from the malignant tumors of bone.

Several consecutive telangiectases may occur in the same individual. Hutchinson, of London, reports the case of a child which had over one hundred nævi, all distinct and superficial. Vascular tumors on the scalp have an element of danger not present in angeiomata elsewhere, in that they at times grow to such an extent as to cause necrosis of the calvaria.

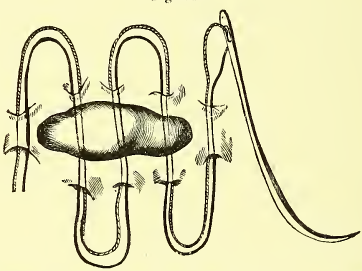
*Treatment.*—Angeiomata have been known to heal without surgical interference, as a result of an idiopathic inflammation. Transfixion and multiple deligation is one of the most radical and successful methods of treatment. Direct and prolonged pressure has been employed, though not with encouraging results. Perforation with hot needles, either with or without the galvanic current, injection of coagulating fluids, particularly Monsel's solution, or of ergot, local applications of nitric acid or other escharotics, and extirpation by the knife, have all been practised. Vaccination over the growth has effected a cure in a few cases.

In treating superficial angeiomata, not too extensive, and not situated where the cicatrix would prove a deformity, Billroth prefers nitric acid. For extensive simple and cavernous angeiomata, he recommends the knife or scissors.

Hemorrhage is to be controlled by pressure, rapid use of forceps, or preliminary ligature.

Angeioma of the face is best relieved by the clean cut of the knife, and the cicatrix is less deforming than that produced by other modes of treatment. I recently removed a growth of this kind from the forehead of a young woman. The incision was made down to the bone, and the tissue removed was more than one inch long by three-quarters of an inch in width. The hemorrhage was insignificant, and the edges united by first intention with an imperceptible cicatrix. Of course the operation is not justifiable if telangiectasis involves more surface than can be covered by stretching or sliding the sound integument. When the skin is not deeply involved in the disease, a crucial incision may be made, and the skin dissected off, and replaced after the tumor has been ligatured and removed. In cavernous tumors of large size the method of Erichsen is advisable. A long straight or slightly curved needle, armed with a double thread, one-half of which is stained black, is passed through the tumor at its base, and deeply from side to side. This process is repeated at intervals of three-quarters of an inch, until the entire angeioma is transfixed with threads which are parallel with each other. The loops are then divided—the black on one side and the white on the other—and tied tightly until the strangulation is complete. It is advised to blacken one-half of the thread, so that in tying the knots a mistake may not be made. The black and white threads are tied separately.

Fig. 532.



Erichsen's method of introducing the double ligature for the cure of vascular tumors.

For my own part, I prefer complete and radical excision in all angeiomata of the face and exposed portions of the body, the removal of which would not cause too great or perceptible deformity. The wound should be carefully adjusted with sutures.

In cavernous tumors of large size, the method of Erichsen is preferable. If these operations are not admissible, then direct pressure or deligation of the main trunk may be resorted to.[1]

Venous Varix, Varix, or Varicose Vein.—This variety of "vascular tumor" consists of a dilatation and elongation of the deep or subcutaneous veins. This condition may exist in any portion of the body, even in the bones (Cornil and Ranvier). It may involve a small portion of one vein, superficial or deep, or, as is most usual, a chain of veins. It is most frequently observed in

[1] For further remarks on the treatment of angeiomata, see the section on Cirsoid Arterial Tumor and the observations following the table of cases there given.

the superficial veins, though Verneuil says that varix is really as common in the deep-seated as in the superficial vessels (Bryant). It is especially prone to occur in the saphena veins. Hemorrhoids and varicoceles are common forms of varix. Unusual types are the dilatation of the jugulars from stenosis of the vena cava descendens, and that of the superficial abdominal veins from stenosis of the ascending cava. Such conditions are described by some authors as simple hypertrophies or dilatations of veins. Any long-continued dilatation constitutes a varix. Hyperplasia of the normal tissues of the venous wall is the natural sequence of prolonged pressure and increased function. The hypertrophy of the wall is not always equal to the resistance of the increased pressure; hence sacculated pouches occur when the vessel wall becomes much thinner than normal, not infrequently resulting in rupture. Varix is of frequent occurrence in women who have had repeated pregnancies (Billroth).

Poorly-fed and hard-worked persons, especially those who work in the upright posture, are more prone to varix than others. There can be no doubt that gravitation is the chief and immediate cause of this disease. The veins most subject to the greatest, prolonged blood-weight, and least protected by pressure, are involved in the great majority of cases. Paralysis of the muscular walls, either by atrophy of the muscles or interference with the function of the *nervi vasorum*, may cause varix. This is proven by the fact that a small segment of a single vein in the upper portion of the body, where the anastomosis is free and gravitation cannot be considered as a factor in the dilatation, may be the seat of this affection.

Mr. Gay says that "with superficial varicosity there are other serious lesions affecting both arteries and veins, deep and superficial, such as would lead to the conclusion that the general circulation has been subject to a very considerable and long-standing embarrassment, some incompetency of the arterial system, or impediment to the venous, or both combined" (Bryant).

In well-marked *varix* the veins are greatly increased, not only in calibre but in length, so that they seem coiled and twisted upon themselves in knotted masses. They are narrowed in calibre at frequent intervals, these contractions opening into expanded pouches, in general appearance not unlike the sacculated large intestine. The valves are wholly inefficient, often flattened against the wall, or at times partially destroyed. At the level of the valves the walls are exceptionally thickened. The thickening is due to a multiplication of the muscular elements and hyperplasia of the connective tissue. The connective-tissue new formation is abundantly distributed in the meshes of the elastic network, and the bundles of fibres are usually arranged parallel with the long axis of the vessel. This accounts for the longitudinal ridges seen on the inner surface of the affected veins (Cornil and Ranvier). Even the nutrient vessels of the walls of these varicose veins—the *vasa vasorum*—have undergone hypertrophy, and are themselves the seat of varix, forming at times venous caverns in the wall of the vessel, which communicate with the vein. The internal tunic is not, properly speaking, thickened, except at the points of attachment of the valves, or when a thrombus has formed.

Immediately external to the middle elastic tunic, the muscular tissue appears increased in quantity, arranged in transverse and perpendicular laminæ, separated by bundles of hypertrophied connective tissue, which are not infrequently stained with granular pigment. Calcareous deposits occur primarily within or between these connective-tissue bundles (Cornil and Ranvier).[1]

[1] In the arteries, these deposits occur first around and within the nucleus of the unstriped muscle, and gradually increase until they fill the cell, which becomes converted into a small calcareous flake (Green). See section on Arteritis.

Hyperplasia of the connective and other tissues in the immediate vicinity of a varix of long standing, presents the usual appearances of phlegmon and elephantiasis. Small spots of ulceration occur as a result of malnutrition, and, coalescing, form the large and obstinate ulcers seen so frequently in varix of the legs. Even a new formation of bone may result from the irritation of a neighboring varicosity (Cornil and Ranvier). The veins become greatly elongated and assume different shapes, irregularly sinuous or corkscrew-like, twisted upon their axes, and frequently, on account of perivascular inflammation, matted together by new-formed connective tissue into venous tumors. Occlusion of varicose veins may result from thrombosis, and a cure may thus ensue. Frequently concretions are found in varicose veins, at times adherent to the walls. These concretions are called *phlebolithes* or *phlebolites* (Dunglison). They are laminated on section, and are said to contain by analysis twenty per cent. of protein matter, with phosphate and sulphate of lime and sulphate of potassium (Franklin and Bryant), and, according to Gross, a trace of oxide of iron. They are found most frequently in the veins of the pelvis, about the bladder and prostate, especially when the latter is enlarged. Hodgson says that they are formed in other tissues, and work their way into the vessels. This theory would seem to receive a partial support from the statement just made that they are most frequently found near the prostate, and when this organ is diseased. It is well known that small calculi are frequent in this body. I have removed, after death, as many as a dozen from ulcerated pouches in a single prostate. Phlebolites are also found in veins not subject to varix. Cruveilhier believed that they were developed from coagula (Holmes).

It may be deduced from these various statements, that, as a rule, these masses are formed from the blood in an abnormal condition, by a process of calcareous degeneration. Occasionally, extra-vascular concretions may find their way into the veins, more especially those of the prostatic and vesical plexuses.

*Treatment.*—Varicose veins are to be treated chiefly by artificial support to the weakened and dilated walls. Eczema and the various forms of ulcer occurring in connection with varix are relieved by proper support. The varix, however, is not often cured by this means alone, which is merely palliative. Martin's elastic bandage is of great use. Bandages of muslin or flannel, properly applied, give great relief. The elastic, knit-worsted apparatus, for constant, equable pressure, cleanliness, and comfort, cannot be surpassed in the treatment of varix. The relief of pressure by position is always advisable. All supporting apparatus should be removed at bedtime and adjusted before rising. The only method of radical cure is by occlusion. This must be accomplished by inducing coagulation of the blood. It is never without an element of danger, since phlebitis is apt to occur. I have used, with benefit, the hypodermic injection of the fluid extract of ergot into the perivascular tissues. The patient was partially relieved, but I was fearful of thrombosis, and desisted after two operations. The use of a subcutaneous, metallic ligature, the wire being passed under and not through the veins, and acupressure, are the most approved methods. The cases are, however, exceedingly rare where such procedures are justifiable. Numerous deaths have followed from the phlebitis or thrombosis which has resulted from these operations. Varices have also been opened and burned with the actual cautery, tied between two ligatures and cut out, treated by compression after incision, etc. Paré speaks of the danger of interfering with varices, lest suffocation should occur. He had probably seen some cases of pulmonary embolism.

Caustics have been used by Mayo, Brodie, Key, and others (Bryant),

and this is the treatment employed by S. D. Gross, who recommends issues made over the varicosity by repeated applications of Vienna paste. His method is to take pieces of the paste as large as a three-cent coin, only much thicker, and to place them directly over the tortuous and enlarged vessels, at intervals of three, four, or five inches, and allow them to remain for fifteen minutes, at the end of which time the skin and connective tissue will be found to have been thoroughly destroyed. The paste is then removed, and the parts washed with vinegar to neutralize any excess of the alkali. Poultices are applied to accelerate the separation of the eschars, and to promote granulations. Prof. Gross says that the cure is usually somewhat tedious on account of the length of time required to heal the issues, but that this plan of treatment possesses the great advantage of being entirely free from danger, and always perfectly successful.

In spite of the commendation of this procedure by so eminent a surgeon, I am not willing to practise it or advise it. It is of necessity much more painful than cutting openly and directly down upon the varix, and tying the veins thoroughly. The cure, in this operation, must come from inflammation and occlusion, partial or complete. The chances of embolism and extensive phlebitis are certainly less than when the inflammatory process gradually approaches and involves a vessel through which the blood is flowing toward the heart. The application of Bozeman's button-suture, Isaacs's injection of subsulphate of iron, Bryant's tannin injection, and Bartholow's perivascular employment of ergotine, are other methods which have been resorted to in this affection.

## Moles.

Closely connected with the more superficial forms of vascular tumor are the abnormal, circumscribed hypertrophies of the skin, which are known as *moles.* They may be, and usually are, congenital, or they may be developed at any period of extra-uterine life. All portions of the cuticular surface may be subject to this form of hypertrophy, but the exposed surfaces, such as the face, neck, and hands, are most frequently affected. The hypertrophy which constitutes the mole may involve all or any one of the tissues which enter into the anatomy of the integument. The most frequent variety is that which occupies the face, as a simple elevation from which a few stiff hairs grow. It is not stained with pigment, and differs very slightly, if at all, in color from the normal skin. The lesion here is a true hypertrophy of all the tissues of the skin, chiefly in the derma and papillary layer. The vascularity is slightly increased, and the sebaceous glands connected with the hair follicles take part in the hypertrophy. On other portions of the body this form of mole (*nævus vulgaris*) will have no hairs growing from its surface.

*Nævus pigmentosus* is not usually a thickening of the entire cutis, as is the simple mole just described, but its pathological condition is an excessive deposit of pigment in the Malpighian layer and in the epidermis. It varies in color from a slate-gray to a blue, mahogany, reddish-brown, or wine color. At times the pigment mole will extend over a large area, occupying as much as one-third, or one-half of the face. The lobule of the ear, and the integument between the eyes and over the temple, is, in my experience, the most common location of this deformity. Another name for these spots is "*port-wine mark.*"

When the hypertrophied area of skin is studded with hairs, it is known as *nævus pilosus*, or hairy mole. It follows from the name that this form of hypertrophy can only occur on those portions of the cutis in which the hairs grow. The plantar surfaces of the feet and the palms of the hands

are never affected. They may or not be stained with pigment. The majority of hairy moles are not colored.

Moles, whether simple, hairy, or pigmented, are benign. As a result of irritation they may inflame and become ulcerated, or may develop into malignant growths. Carcinomata, especially of the melanotic variety, are frequently described as having resulted from inflamed pigment moles. Alarming hemorrhage has been known to occur from a mole more than usually vascular, in which ulceration had been established by friction of the clothing.

*Treatment.*—As long as no deformity or inconvenience results from these formations, it is better to let them alone. When situated upon the face, of such size or position that they become offensive to the eye, they may be removed by simple excision. The incision should be elliptical, and well away from the growth, going entirely through the thickness of the skin. The wound should be closed with a delicate suture, or drawn nicely together with adhesive strips. I have removed as many as five from the face of one patient, and without leaving any perceptible trace of their location; and no bad result has ever occurred to my knowledge from this practice. The simplest method of procedure is to produce local anæsthesia by the ether spray, and operate quickly. *Port-wine marks*, that is, large pigment spots, may also be excised when the surgeon is assured that the resulting cicatrix will be a less deformity than the existing mole.

If a mole should at any time take on inflammatory action, or give any indication of malignant proliferation, immediate excision would be imperative, and the incision should be wide of the supposed area of the disease. The employment of caustics or irritants of any kind is to be deprecated, as they would increase the tendency to malignant change in these growths.

# ANEURISM.

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## Definition and Classification.

The attempt to define aneurism encounters considerable difficulty, because many different forms of disease are included under that word; and because much of our terminology has descended to us from older writers to whom the circulation of the blood was unknown. Probably the only definition which, while excluding every other malady, includes all varieties of the disease in question, will be found to run thus: *Aneurism is a blood-tumor directly communicating with the interior of one or more vessels on the arterial side of the circulation.*[1] Some of these tumors are formed by more or less uniform dilatation of a certain length of a vessel, or of vessels, the blood being within the vascular lumen. Some are formed by blood lying outside the normal area of the circulation, but still inclosed in one or more of the vascular coverings; others are formed by blood which has become extravascular. Any of these forms may be complicated by preternatural communication with a vein, the disease being then termed *arterio-venous aneurism.*

But, although such distinctions are anatomical, and satisfy all requirements of definition, they are in a clinical point of view all but useless. To make out during life whether one or two of the vascular coats entirely include the blood of the tumor, or whether those coverings have given way over a larger or smaller spot, is impossible; and the distinction, could it be made, would be valueless. Sometimes, indeed, all the three coats will have yielded, and yet the blood be contained in a definite cavity, the tumor presenting the same signs as though one or more of the arterial coats persisted. Although I think, therefore, that certain anatomical distinctions had better be forgotten, or merely considered as curious historical lore, yet it is necessary in a work of this nature—as the names have not yet been relegated to the past—to give under a sort of protest the distinguishing terms of true and false aneurism, as applied to the different conditions of the arterial coats in this disease.

A "*True Aneurism*" is one in which all the three tunics of the vessel are entire and continuous throughout the tumor. A "*False Aneurism*" is that form in which one or more of the coats are no longer entire. Not only, however, is the distinction impossible during life, but in many instances after death also; for during the progress of disease the distended vascular coverings undergo such changes as to render them quite unrecognizable: they may some-

[1] I am of course aware that such a definition would include certain of the larger nævi (angeiomata), as also some recent and increasing ecchymoses. But, as will be seen in the sequel, such angeiomata are not anatomically distinguishable from small aneurisms by anastomosis, nor does such an ecchymosis, if the blood come from an arterial twig, differ from diffuse aneurism otherwise than by its size.

times be split into any number of coats, sometimes only one can be found, sometimes it is impossible to determine whether one of the coverings is a normal part or an entirely fresh formation.[1] Let us therefore at once, and throughout this article, discard the terms false and true aneurism, with the remark that a dilatation of the whole periphery of an artery is generally constituted by all the vascular coats. A protrusion or bulging of one side or aspect of an artery is, unless merely incipient, accompanied by rupture of one or more coats. Some writers have described a form of false aneurism—"hernial"—the existence of which is more than doubtful. It is, as its name implies, supposed to be formed by the bulging of the inner through an opening in the middle and outer coats. There is, I think, no doubt that a certain false lining often found in diseased arteries has been mistaken for a dilated inner coat, and that preparations supposed to illustrate this condition are the artificial productions of over-zealous dissection.

Better reason might be shown for the term diffuse aneurism, were it used in a more reasonable and consistent manner; but it is, unfortunately, applied to such tumors as are still circumscribed, if at any point the capsule appear to consist not of arterial coats, but of condensed adjacent tissue, and also to unlimited effusion of blood into cavities or tissues resulting from wound or rupture of a healthy or previously diseased artery. Some reform in this nomenclature is urgently needed, and will immediately be supplied. The clinical distinctions of aneurisms, borne out as they are by anatomical facts, are these:—

Fusiform Aneurisms are such tumors as are produced by dilatation or expansion of the whole periphery of an artery. Whether this centrifugal dilatation be or be not uniform, it is always greatest at or about the centre, diminishing towards either end, where it joins the normal tube—it is, therefore, in form biconical or spindle-shaped. A less advanced form of the disease is sometimes termed *aneurismal dilatation*. Such aneurisms have, therefore, two communications with the rest of the vessel—the one proximal, the other distal.

Sacculated Aneurism is that form of the disease which is produced by the expansion of a limited spot on one aspect of an artery, and which has, therefore, but one foramen of communication with the circulating stream; this is nearly always beside the current, like a diverticulum or bay, and is called "the mouth;" around and adjacent to it is the "neck;" and the bulk of the tumor, always larger than the neck, is the "body" of the aneurism. The whole is inclosed by the "sac." A sacculated may spring from a fusiform aneurism, or from an aneurismal dilatation; in such cases the mouth is larger in proportion to the body than when the tumor arises from an artery of normal calibre. This form of aneurism may arise without any traceable immediate cause, and is then called *spontaneous;* or may result from injury—blow, strain, or even direct wound—when it is called *traumatic*, a term concerning which a few words must be said presently.

A Dissecting Aneurism results from an escape of blood through a rent in the inner coverings of an artery, while the outer envelopes are sufficiently strong to resist dilatation. The blood therefore percolates a certain, often a

[1] Mr. Erichsen says that a false aneurism may always be distinguished if on section the middle coat is seen to terminate abruptly in a dense ring immediately round the neck of the sac, and certainly it seems like a truism to say that the edge of a ruptured coat shows that rupture, that is, falsity of aneurism, exists; but I have seen many aneurisms, undoubtedly false, in which no such abrupt edge, no undoubted and definite place of demonstrable rupture, could be traced.

considerable, distance between the walls of the vessel, separating, as it were dissecting, one coat from another, or the two layers of the middle coat from each other. For a certain time, therefore, there is but one foramen of communication with the area of the vessel, but after a while the blood usually perforates the outer coverings and becomes effused; or may, making another breach in the internal tunics, find its way back into the circulation. This form of disease is almost confined to the aorta; but one or two examples have been seen to spread thence into the large branches springing from its arch.

Arterio-Venous Aneurism.—When any of these aneurisms communicates with a vein by an interparietal breach, the condition becomes "*arterio-venous aneurism*," which is of two sorts; when the opening is immediate, with no interposed cavity, the disease is "Aneurismal Varix." When a cavity, blood-filled and circumscribed, opens into both vein and artery, "Varicose Aneurism" is the term employed.

Racemose or Cirsoid Aneurism and Aneurism by Anastomosis are dilatations of numerous and smaller branches, either supplied by one, or more commonly by more than one, vessel. The dilatation extends to what normally are minute ramifications, even capillaries, and affects not only the circumference, but the length of the vessels, which are therefore tortuous. The tumors consist of congeries of convoluted and irregularly dilated vessels twisting and freely anastomosing through a certain district of thinned and softened tissue.[1]

Diffused Aneurism.—Any of the above forms of aneurism may, by rupture or erosion through some part of the sac wall, permit a greater or less escape of blood into the neighboring tissues; it is then called "diffused." We must in this place make a clear distinction: a sacculated aneurism often grows so rapidly that, at a portion of its periphery, all the arterial tunics incapable of such wide dilatation have given way, and a portion of the sac is formed by the adjacent tissues thickened by previous pressure, with perhaps inflammation, and reinforced by the coagulation of blood which has infiltrated among them. Bone, muscle, fascia, etc., may thus form a portion of the sac; but be it observed that there is a sac: the blood is encapsuled. On the other hand, it sometimes happens that the sac, however formed, gives way more completely, and permits the effusion of blood without limit among the tissues. The former condition is properly called a consecutive aneurism (Broca); the latter is often termed a diffuse aneurism; it is said to have become diffuse. I think that the term should be limited to small effusions slowly produced, and that the name "ruptured aneurism" would better represent the large and sudden outflow of blood which sometimes occurs.

It may be gathered from the above, that a diffuse aneurism may, if not too large, become re-encapsuled by coagulation of its outer portion, and by inflammatory thickening of the surrounding tissues. An arterial wound, for instance, may pour out a certain quantity of blood into the tissues; the skin opening may be closed by nature or art, while pressure may check the bleeding; the effused blood after a time becomes encapsuled, and the result is a *traumatic consecutive aneurism*.

The term traumatic diffuse aneurism, applied to a wounded or ruptured vessel filling the whole neighborhood with limitless (not encapsuled) blood, is evidently a misnomer; some sort of sac is inherent to the idea aneurism, and what has been so injudiciously named as above, is a wounded or ruptured

[1] This subject is treated of in the article on Diseases of the Vascular System.

artery with interstitial or subfascial hemorrhage. The term will not be used in this article.

Another distinction is drawn from the locality of the disease. *Internal* aneurisms are situated within the cranium, thorax, or abdomen, while those that make their appearance outside those cavities, or anywhere about the limbs, are named *external* aneurisms. The region in, or the artery on which, the tumor is situated, also confers a name on the disease: thus, intracranial, thoracic, or abdominal; axillary or popliteal; aortic, carotid, femoral, and so on.

## Causes of Aneurism.

The *causes* of aneurism are (1) wound or violence,[1] and (2) any circumstances which disturb the relationship between the pressure of the blood and the retentive power of the vessels. Among the latter there may be certain predisposing as distinguished from direct or exciting causes, but they vary in different events; thus, for instance, atheroma may be merely a predisposing cause, if some violence produce the disease, but is in spontaneous aneurism more frequently the exciting, indeed the only direct, cause; the predisposing causation must then be sought in such conditions as may produce or tend to arterial degeneration. But little notice will, however, be taken of this time-honored division of causes, since it is, as regards aneurism, more pedantic than valuable.

Wounds.—Wounds inflicted by some sharp instrument, although they more commonly give rise to hemorrhage, may, by partial division of arterial coats, cause aneurism, which, if the vein be also implicated, may be arterio-venous, but may also, as the following case will show, be of the sacculated variety, if merely the artery be involved:—

Case I.—A carpenter, aged twenty-six, was admitted into Charing Cross Hospital, under the care of Mr. Canton, in April, 1861. Three weeks previously a chisel which he was using slipped and penetrated the thigh, about the junction of the upper and middle thirds. Some smart but not profuse bleeding occurred, but was checked without deligation of any vessels; the wound healed quickly, and had closed six days before his admission. He came to show a "lump" which lay immediately under the cicatrix, and which was diagnosed to be an aneurism, for which the femoral artery was tied.

The man died; the arterial wound was found to have divided probably only a certain thickness of the outer coat.

External Violence, without Wound, is sometimes directly productive of aneurism. A familiar example of such casualty is found in the axillary aneurism which sometimes follows over-zealous attempts to reduce a dislocation of the shoulder. The vessel indeed may be entirely ruptured by such efforts. Sailors are said to be subject to axillary and subclavian aneurism, sometimes probably the effect of repeated over-exertion, often the result of some sudden effort, as preventing a fall by catching with one hand on a rope or spar. Violent traction by revolving machinery, which, having caught a limb, drags it into its gear, has several times been followed by aneurism. I have, from my own observation, reason to believe that the frequent falls and other mishaps of drunkards produce thoracic and abdominal aneurisms more frequently than is usually supposed. In such cases, it is probable that some form of degeneration may have weakened the arterial coats; perhaps alco-

[1] I avoid the word traumatic as in this case ambiguous.

holic paralysis, since the poison is in contact with the vascular walls, may affect their muscular fibres sooner than the voluntary organs, thus impairing elasticity and power of resistance. To this subject we must recur.

The second class of causes, namely, disturbance in the ratio between blood-pressure and strength of tunics, falls naturally into two subdivisions; the first is increased mass or pressure of the blood, general or local. I am not aware that either the plethora or the high arterial tension that accompanies Bright's disease has ever been shown to be directly productive of aneurism; and I must say the same of hypertrophy of the left ventricle.[1] Aortic aneurism and ventricular hypertrophy are frequently coexistent; but either may cause the other, and the walls of the vessel are in such cases very rarely if ever healthy.

It is certain that any circumstance which increases the propulsive action of the heart, must in so far conduce to aneurism; but that "in so far" goes very little way, unless the cardiac over-action be assisted by a *vis a fronte;* the force of the heart alone is unable to produce aneurism unless of a very diseased artery. This *vis a fronte* may be supplied by violent muscular efforts preventing capillary ingress; by over-tight clothing; by an infelicitous posture at the moment of exertion, suddenly occluding the artery; or perhaps by the impaction of an embolus.

Muscular Effort.—The effect of over-exertion is well known; a simple act of this kind may produce the first distension or rupture of the middle coat, very slight perhaps, which repeated similar efforts may afterwards increase. The greater prevalence of aneurism in the male than in the female sex is the result of the hard muscular exertions more frequent among members of the former.

Constriction by Clothing, etc.—The effect of over-tight clothing is well exemplified by the prevalence of aneurism in the army. Mr. Myers has shown,[2] I think, conclusively that this prevalence is due not as is often asserted to syphilis, but to over-tight uniforms, especially to the stock; for syphilis and over-exertion are equally common in the navy—but aneurism is per 1000 men $13\frac{1}{2}$ times more frequent in the former than in the latter service.[3] The effect of constriction on the neck or limbs must be a certain obstruction to the blood-stream along the vessels, and also a hindrance to elastic yielding of the arteries to different postures; so that sometimes the coats will be stretched lengthwise, perhaps to their uttermost, while a large wave expands them centrifugally.

The frequency of aneurism on the flexor side of much-used joints has been often noticed, and has been ascribed to the frequently produced sharp curve in the artery—obstructing the blood-current by the *vis a fronte* just mentioned. It must, however, be observed that this peculiarity is much more marked in the lower than in the upper limb, although the flexed posture is quite as often assumed in the latter as in the former; therefore position can hardly be the apparent cause, and a case about to be quoted tends to refute the theory, also often advanced as an addition to the posture hypothesis, of a greater muscular power and exertion of the lower limb. Popliteal aneurism is very frequently double, and not much less frequent is its recurrence, after cure on

[1] The word directly is used in the text because there is little doubt, as will be seen in the sequel, that excess of blood pressure may, by inducing certain forms of arterial disease, indirectly conduce to aneurism.

[2] Lancet, Feb. 20, 1869.

[3] This subject will be further mentioned presently.

one side, in the other limb. The number of such cases to be found recorded in medical journals, is too large to quote; the occurrence has been ascribed to the mode of walking adopted by the patient, which, in order to spare the previously diseased side, throws additional exertion on the hitherto sound one, which therefore soon begins to suffer. The case related by Mr. Humphry, though it does not negative the possibility of such causation, at all events in part, shows very clearly that there is some other agent at work:—

Case II.—The patient, a laborer, 37 years old, suffered from right popliteal aneurism. Mr. Humphry tied the superficial femoral artery with catgut; secondary bleeding occurred and recurred more than once, so that the man was very greatly reduced; the action of his heart was of course very weak; he was at rest in bed, and yet during a state and period which would appear most unfavorable to the production of any aneurism, a fresh one was developed in the popliteal space of the left limb.[1]

The tendency to form double popliteal aneurisms does not depend upon an "aneurismal diathesis," nor on any general vascular degeneration. The persons who thus suffer do not, as a rule, engender the same disease on other vessels. There must, then, be some local condition—beyond mere frequency of flexion, muscular exertion, etc.—which renders this the most common form of all aneurisms, and which causes it to be so frequently double. Now the brachial artery at the elbow—quite as frequently bent as the popliteal at the knee—lies at some little distance from the bone, and is protected from it by considerable thickness of muscle, etc. Behind the knee, the vessel lies between the femoral condyles and in the popliteal notch of the tibia, close, therefore, to very hard structures, against which every pulse drives its front wall—a condition peculiarly likely to slowly damage its tunics. Mr. Barker showed, at the Pathological Society,[2] a remarkable instance of arterial disease, affecting both sides nearly symmetrically, and pointed out that wherever the vessels lay against hard bone, the affection was most marked. His inferences will be again referred to.

Posture.—Another occasional cause of aneurism is some infelicitous posture obstructing a vessel at the very moment of some strenuous exertion, as may be instanced by the following case:—

Case III.—Mr. B. was a thoroughly sound and healthy man, save that he had had acute rheumatism 25 years before, which left no trouble save occasional attacks of rheumatic pains. No signs of vascular disease were to be detected. He was 40 years old, was non-syphilitic, unmarried, very temperate, accustomed to a fair amount of exercise, being a good cricketer, skater, and runner. He was giving a rather heavy child a ride on his foot, one knee being crossed over the other. He had no sense of something giving way, but felt suddenly that he must desist, and soon after was aware of weakness and a sense of fulness behind the knee-joint of the limb on which the child had sat. Two days afterwards he found a swelling at that place, of which at first he took no notice; but finding it, during the week, to increase rather rapidly, he consulted an excellent provincial surgeon, who pronounced it to be aneurism. I saw him a few days afterwards, and found the diagnosis to be quite correct, the tumor lying low in the popliteal space and having but thin walls.

In other cases, the position acts not so much by causing an obstruction in the lumen of the vessel, as by binding it down and preventing it from yielding in the direction of limb-movement. For instance, in a bent limb, the vessel is shorter than in a straight one; but if it become somewhat fixed in that shortened posture by an old cicatrix, or by the pressure of clothing, bandage,

[1] British Medical Journal, 1876, vol. i. p. 599.
[2] Transactions, vol. xxviii. p. 86.

or strap, and then the joint be forcibly extended, the vessel cannot follow the movement, will become stretched beyond its proper degree of yielding, and will be very likely to have its middle coat torn across; that is to say, between the transverse fibres. A sudden increased heart-action at the moment when, by such stretching, the tube is rendered rigid and narrow, must assist in producing this result. A like curtailment of the yielding quality results occasionally from the healing of old inflammatory mischief or of abscess around a vessel; the cicatricial tissue, binding the outer coat to a more or less unyielding structure, renders the artery liable to rupture, as those who have to deal with anchylosed joints are aware. That arteries, even when healthy, can bear only a certain amount of stretching, is proved by the experiment of Richerand, quoted by Hodgson,[1] and also by Holmes,[2] namely, the application in the dead subject of such hyperextension to the knee as shall cause the ligaments to crack; dissection will then very generally show that the two inner coats of the popliteal artery are entirely or partly torn through. Another illustration may be taken from certain mishaps that have occurred during overzealous attempts to reduce dislocations of the shoulder.[3]

EMBOLISM.—Sudden check to the arterial current through a limb by the impaction of an embolus, has been alleged as a cause of aneurism; but I think on insufficient evidence. Mr. Tufnell's case[4] seems to me rather to show the difficulty of such occurrence. A man suffering from acute rheumatism developed suddenly a pulsating tumor in the popliteal space, which quickly subsided as collateral vessels became developed. After death, a very slight dilatation of the artery, plugged with fibrine, was found, proving that even when a systemic artery does enlarge from the lodgment of an embolus, only a transient dilatation—not an aneurism—is produced. Dr. Goodhart happened to have his finger on a rheumatic patient's pulse when it suddenly stopped. It is not recorded that any tumefaction was observed at the time. Some days after (period not recorded), the man died, when it was found that "the left brachial artery was considerably distended at the bifurcation, and, on opening it up, a white, creamy fluid escaped, like pus, and having the microscopic features of pus. The lumen of the vessel was dilated and its walls soft."[5] This suppurating vessel with softened walls can hardly be termed an aneurism. In the same volume of pathological records (page 98), are two cases, considered embolic by Mr. Bryant; the first was a case of ruptured femoral artery occurring in a rheumatic subject after a stumble, there being proof neither of aneurism nor of embolus; the second, also in a rheumatic subject, was a case of popliteal aneurism arising after some exertion. In Mr. Holmes's case,[6] there was an ulnar aneurism and endocarditis (warty); there were, too, embolic clots in the kidney and spleen; but I cannot see any proof

[1] Diseases of Arteries, p. 64.

[2] System of Surgery, vol. iii. p. 418.

[3] I have computed arterial elasticity thus: The subject, placed on the back, has a thick block under the shoulders, permitting the head to hang back as far as it will go (rigor mortis being eliminated). An assistant holds the points of a pair of compasses two inches apart on the bared common carotid; close to each point a pair of scissors is placed, the blades embracing the vessel; then at a given moment the vessel is severed simultaneously at the two points. The separated piece, which, while *in situ* in the posture described, measured two inches, now measures about an inch and a half. Thus:—

| Sex. | Age. | Cause of death. | Piece measured. |
|---|---|---|---|
| Male | 43 | Violence | $1\frac{1}{2}$ inches. |
| " | 30 | " | $1\frac{3}{8}$ " |
| Female | 27 | Phthisis | $1\frac{7}{8}$ " |
| Male | 51 | Bronchitis | $1\frac{1}{2}$ " |

[4] Dublin Quarterly Journal, May, 1853.

[5] Pathological Transactions, vol. xxviii. p. 108.

[6] System of Surgery, vol. iii. p. 423.

that the aneurism of the ulnar artery was due to embolus, or that any such substance ever got into that artery. I, of course, do not mean to deny that emboli become occasionally lodged in the systemic vessels, but I doubt if they can cause aneurism.[1]

I do not think that stoppage of the blood stream, even if it were complete, could cause a healthy and uninjured artery to dilate rapidly into an aneurismal swelling. The dilatation, be it observed, must be rapid, for the strain upon the vessel becomes, as in Mr. Tufnell's case, very soon relieved by the development of collateral channels.

In the above paragraphs I have endeavored carefully to limit my remarks to systemic vessels—namely, those of the trunk and limbs—excluding visceral arteries; for the matter stands, undoubtedly, very differently in regard to such vessels. The thinly coated arteries of the brain, and in a less degree of the abdominal viscera, are much more easily affected by a centrifugal expansile force; they are, too, especially the former, less firmly supported by adjacent parts. For such reason, they are certainly not very infrequently the subject of embolic aneurism, as was first pointed out in the original and valuable paper of Dr. Kirkes. Numerous instances of cerebral apoplexy from burst aneurism, concurrent with fibrinous concreta from endocarditis, have been recorded,[2] while Drs. Ogle and Wilks have described cases of aneurism of the superior mesenteric artery with like association.[3] Dr. Ponfick has written an excellent paper on the subject,[4] in which he very clearly traces the connection between warty (verrucöse) endocarditis and arterial embolus. He gives 6 cases, 4 of which were in the brain, 1 in a small branch of the splenic, 1 in a primary branch of the superior mesenteric artery. The singular prevalence of such aneurisms in the brain is, no doubt, in part accounted for by the curious tendency of floating solids to run up the left carotid; but this does not dispose of the abdominal cases, the fact being that emboli once beyond the aortic arch are just as likely to flow into the iliacs as into the visceral arteries. In the latter thin vessels, they may, if well placed, produce aneurism; in the former, they cause gangrene, or tendency to gangrene, or a peculiar tingling, painful condition of vessels beyond (see Case IV.), hardly distinguishable from subacute arteritis. It is singular that none of these phenomena were observed in the above cases of supposed embolic aneurism.

Atheroma and Ossification.—But these extraneous causes of aneurism—occasional only, and some of them problematical—are less important than certain changes of the arterial coats, which so weaken them as to render their expansion or rupture almost inevitable, or at least extremely facile. This change, either atheroma or ossification, producing a weakening or rigidity of the arterial coats, has been ascribed to different pathological events, and located in various anatomical portions of the tunics. It would lead to little advantage were descriptions of all the views held by different writers here detailed. Rokitansky,[5] and, following him, Mr. Moore,[6] consid-

[1] Mr. Holmes says, "that the objection often urged, viz., that aneurisms do not form on arteries suddenly obstructed by ligature. is an unsound one, since they do so form, although rarely." Here I must take leave to differ. When such occurrence takes place, it does so because the middle coat is divided. An impacted embolus can hardly so entirely block the vessel as a ligature, nor does it sever the tunics. For some other opinions I must refer to the volume of the Pathological Transactions above quoted.

[2] Holmes, Gowers, Goodhart, Ogle: Pathological Transactions, vol. xii. p. 61; vol. xxviii. p. 107; vol. xviii. Wilks, Morbid Anatomy. Gull, Guy's Hosp. Reports, 3d ser. vol. v.

[3] Pathol. Trans., vol. viii. p. 168, and vol. xi. p. 44.

[4] Virchow's Archiv, Bd. lviii. S. 546.

[5] Ueber einige der wichtigsten Krankheiten der Arterien, S. 2.

[6] Holmes's System of Surgery, vol. iii. p. 393.

ered a deposit from the blood (Auflagerung) to be the initial step. But since the appearance of the Cellular Pathology of Virchow, whose views are followed by Niemeyer[1] and Moxon,[2] it appears that the inflammatory nature of both atheroma and ossification must be accepted; the Berlin Professor's excellent account of the condition, traced from its initial to its terminal phases, can hardly be improved.

PERI-ARTERITIS.—Disease of the outer arterial tunic, *peri-arteritis*, is of small importance; it is nearly always consecutive to, and directly dependent upon, inflammation of the neighboring tissues, as in suppurative or phlegmonous inflammation. The possibility of abscess opening into arteries is undoubted, and will again be mentioned, while the diminution of extensibility which may arise from adhesion of the outer coat to surrounding inflammatory thickenings, has together with its effects been already discussed.

The middle coat generally participates in the diseases of both the outer and the inner tunic, and we know nothing of any active disease affecting this structure independently. But we do know a good deal of a fatty degeneration which not unfrequently attacks, and is for some time confined to, the middle coat. It assumes the simple form of such degeneration, as we see it in the muscles of the heart, in the articular cartilages, or other cellular organs: namely, a massing of oil molecules, at first within the lumen of, then also around, the cell. It is this condition which gives rise to long and but little accentuated fusiform aneurisms, or to aneurismal dilatations, and is, in all probability, the constant cause of multiplicity of aneurisms—the aneurismal diathesis. Moreover, irrepressible, consecutive and secondary hemorrhages have very commonly a similar origin.

ENDARTERITIS is, however, the most important of all the arterial diseases with which we have to do; it may be either acute or chronic, though acute endarteritis is certainly very rare.[3]

I have never seen an idiopathic case of the malady in an open artery, but several instances of plugging and subsequent endarteritis have come under my notice. Of traumatic endarteritis I can give the following very striking example:—

CASE IV.—R. W. was a man for whom I had tied the right carotid and subclavian arteries. Twenty-six days afterwards he complained of a burning and aching pain along the course of the brachial, ulnar, and radial vessels of that side. The temperature had varied from 97° to 102° Fahr., morning and evening. His diet had, till six days previous, been dry and restricted, but was at this time an ordinary full diet. He had no pulse either at the wrist, or in the brachial or lower part of the axillary artery. On the morning of the 9th of September, the day in question, he complained of peculiar, hot, tingling pain from the shoulder to the hand, along the course of the arteries, which felt hard

[1] Lehrbuch der speciellen Pathologie und Therapie, 9te Auflage, Bd. i. S. 357.

[2] Guy's Hospital Reports, 3d series, vol. xvi. p. 431 *et seq.*

[3] Some surgical writers describe acute or subacute arteritis, its symptoms and effects, in a manner which facts, as far as we know them, do not authorize. The "plastic or embolic arteritis" described by Erichsen, and for proof of the existence of which he refers to the effects of pressure, as by a tumor, or the action of a ligature, never arises *suâ sponte* in a previously healthy artery, though plugging by an embolus from the heart, or occlusion by pressure, will cause coagula to form, and subsequently to become adherent to the now disused vessel. The inner coats of an artery tied with silk, are divided, and the wound throws out an adhesive material; but there is no reason to believe that any part of an acting and still patent artery can become gradually occluded by the solidification of fibrine thrown out from its own inner surface. Neither clinical nor pathological observation can furnish a single instance of such an occurrence. Mr. Erichsen, in his two short paragraphs concerning plastic endarteritis (Science and Art of Surgery, vol. ii. pp. 1–3), appears to me to have overlooked the presence of the intra-vascular wound in tied arteries, and there is therefore a *non-sequitur* involved in his second proposition.

and cord-like, and were very tender. That evening his temperature *decreased* to 96.4°, and afterwards remained normal. A slight stimulation of the skin with ammonia liniment was followed in three days by relief. On the 23d it was noted (I being absent) that the axillary and brachial arteries were swollen, hard, and excessively tender; their enlargement was even visible; they were painted with tincture of iodine; the pain and swelling disappeared in three days.

As other conditions more grave than the localized arteritis were probably affecting the temperature, little stress can be laid on the constitutional symptoms; but it is remarkable that the thermometer declined to below the normal standard on the evening when the above symptoms were complained of. It is also to be observed that this occurrence took place in empty vessels, and perhaps might be the natural result of nature's successful effort to close, by inflammation or adhesion, useless tubes. A slighter instance, following in all probability the impaction of an embolus, also occurred in my practice:—

Case V.—Edward E., aged 46, stationer, was admitted under my care into Charing Cross Hospital, December 19, 1880. The man's father died of heart disease; he himself has always led a regular and temperate life, and has never had syphilis. Twelve years ago he had "rheumatic gout" (probably a smart attack of subacute rheumatism); he has of late suffered from palpitation of the heart. On December 11, he gave a lad a back-handed box on the ear. Half an hour afterwards, while using a small plane, he noticed that his fingers became contracted and his hand weak; afterwards the arm felt very tired, with tingling and aching. Next day, on washing in cold water, the 3d and 4th fingers "went dead" (the weather at the time was unusually mild). The sense of weakness and the aching increased slightly up to the time of admission. No pyrexia; hand cold. December 17.—The beat of the right radial pulse was barely perceptible, that of the left one normal; the man complained of pain and tingling from the elbow to the axilla, along the course of the vessels and nerves; a cord-like enlargement of the artery could here be distinguished. Dec. 18.—The pain up the inner side of the arm and along the front of the forearm was, he says, considerable during the night; to-day there was no pulse at all in the right radial; a slight hypnotic was ordered, and fomentations. Dec. 19.—I saw the patient for the first time and examined him very carefully. The arm being wrapped in cotton-wool was warm nearly to the elbow, a little lower in front than behind; beyond this boundary the limb became gradually cooler; the hand was cold. Both the radial and ulnar arteries were rather hard to the touch; neither pulsated; above the elbow, a round, not very firm, cord could be felt in the position of the brachial artery, not pulsating, but full; pain as well as tenderness was here complained of. The heart's action was very irregular (Dr. Bruce's report as to the heart is given at the end of the case), but I could detect no murmur; perhaps a little enlargement. There was no elevation of temperature; urine, digestion, appetite, etc., were perfectly normal; but the man was of nervous temperament, had read some medical books, used medical terms, and complained of several pains, the existence of which seemed doubtful, though some about the right arm may very likely have been owing to dilating collateral vessels. Dec. 22.—Still continues in much the same state; slept badly, from pain in the testicles. January 4.—Pain and tenderness had gradually diminished; he said the arm still felt weak, and a little numb; the radial, ulnar, and brachial pulse was absent, the brachial artery feeling like a hard cord (a cedar-pencil), movable beneath the skin.

Dr. Mitchell Bruce has been kind enough to give me the following report of the state of Edward E.'s heart. Pulsation very irregular, second sound weak and muffled, some hypertrophy. A distinct murmur at base and apex, coincident with both first and second sounds, indicative of aortic incompetence due in all probability to warty endocarditis.

Chronic endarteritis is one of the most common diseases to which the human subject, after middle life, is prone; the disease itself presents no symptom by which its presence can be inferred: it is known chiefly by its effects. It is most common at the commencement of the aorta, and next in the cerebral branches; but it may arise in any artery, and indeed, in far advanced cases,

every vessel of the body carrying red blood may be affected; those which carry venous blood, and the pulmonary veins, are almost entirely exempt.

The results of the inflammation, characterized by hyperplasia and proliferation in the deeper layer of the inner coat, are two. First, what in the commencement appears like a mere thickening of the tunic, which adheres with unusual tenacity to the underlying structure. This thickened patch, though still covered by epithelium, is somewhat duller, of a more opaque, yellowish-white than the rest of the surface, and elevated above it; in other words, it encroaches on the vascular area. In a later phase of its development, this patch becomes still harder and firmer, semi-cartilaginous in consistence, and puckered on its inner surface, while encroaching more and more on the middle coat whose whole thickness it may ultimately occupy. But it is to be observed that the encroachment does not, at all events till a late stage, diminish the calibre of the vessel, which up to a late phase of the disease is greater than normal, while its length also is increased. The microscope shows this indurated and thickened spot to consist of ramified spindle-cells, intermixed with firm and apparently thickened bands of fibrous tissue continuous on one side or the other with the healthy structure of the surrounding tunic. The elements, cellular as well as fibrous, are at this stage healthy; but sometimes fat globules are interspersed among them.

Another less frequent form is often present on the same artery with the denser thickening; it is distinguished by its jelly-like consistence and pale, pink color; it is more superficial in its origin than the form first described, but still lies beneath the epithelial lining of the vessel, under which it may be pushed a little way hither and thither; it may occur in small patches, or may occupy larger portions of the tissue. The new formation, under the microscope, is seen to consist of oat-shaped and spindle-shaped cells running in lines crossing each other in all directions, and inclosing an amorphous ground substance, studded often with bare nuclei; in fact, it bears the strongest resemblance to granulation tissue.

To the unassisted eye, both these conditions produce on the inner surface of the artery wart-like or hob-nail elevations of various sizes, from that of a mustard-seed to that of a horse-bean, or even larger; these are somewhat flattened towards the area of the vessel, ovoid rather than round, with the long axis in the circumference, or else quite irregular, and in this phase covered by epithelium. Between any two such elevations, especially of the former sort, the inner coat is often puckered, while the middle appears thinned and weak.

The fate of these two varieties is somewhat different, or at least is often different. From my own investigations, I have strong grounds for believing that the latter form not unfrequently hardens and forms a sort of inflammatory or cicatricial tissue, which may then undergo the same ultimate changes as the former species, or may, like all tissue resulting from granulations, shorten and contract, thus producing those puckerings and indentations so frequent on the inner surfaces of large arteries. But occasionally the granulation, if I may so term it, having invaded the deeper layer of the inner, as also a variable thickness of the middle tunic, and having undergone, first on its inner face, a puro-fatty change, eats through the epithelial pellicle, and falls little by little into the blood stream, leaving behind a usually small ulcer, leading into a somewhat larger cavity of a depth equivalent to the amount of its invasion.

The more frequent result of the inflammation—the dense, yellow, semi-cartilaginous thickening—may remain passive a very long time. Large vessels, chiefly the aorta, may be so studded with the projections thus produced that the name *endarteritis deformans*, given by Virchow, is by no means a misnomer.

It is not uncommon to see in the post-mortem room such an aorta, puckered, grooved, and roughened, so that few patches of the surface remain normal; yet no aneurism may be present, although the channel is somewhat widened. If the disease affect some more superficial vessel, the lengthening thereby produced is marked by the undulations and zigzag course of the artery. Nevertheless, the tendency of this new formation is towards degeneration, fatty or calcareous. Both these begin in the deeper layers of the tissue; the former by the gradual accumulation of oil-globules around the nuclei of the proliferating cell, whose walls give way, so that the oil lies among the fibres, which then also degenerate; cholesterine crystals are deposited, and when the process is complete, the whole mass becomes a bag of gruel-like or porridge-like substance—the condition indicated by the word atheroma. If this burst into the vessel through the epithelial covering, it forms the "atheromatous ulcer," which not unfrequently heals, leaving a cicatricial loss of substance. The calcification resulting from the deposit of minute molecules of lime salts in the deeper parts of the firm new tissue, proceeds gradually towards the surface; it sometimes converts the whole patch into lime; sometimes it is accompanied by fatty degeneration of the more superficial parts. In such large vessels as the aorta and its immediate branches, larger or smaller specks only will have become bony; vessels of less calibre may be converted into rigid, bone-like tubes. Occasionally a patch, more especially if fatty degeneration have helped it on its course, may break through the epithelial lining, and lie bare to the blood; sometimes the current getting under such a piece will turn it sideways to the vessel, so that its edge projects into the stream and may gather a clump of fibrine around it, or the whole piece may be washed bodily away from the place of its formation, to be entangled and to form an embolus somewhere in a narrower part of the circulation, while the spot whence it came remains as an ulcer and as a weakened part of the artery.

The effects upon vessels of these different results of inflammation, in their various stages, are these:—

The soft gelatinous growth may, indeed often does, rapidly produce a loss of substance in the vascular walls; if it follow this course, the especial weakness which may give rise to aneurism is produced, and such disease is imminent according to the size of the spot; it is probable that dissecting aneurisms arise in places thus affected; if, on the other hand, the granulations harden into new tissue, the artery at that spot is strengthened, but with loss of elasticity.

The semi-cartilaginous thickening, while it remains hard and dense, also strengthens that particular point of the artery, but likewise with loss of elasticity. When the new material softens, that part of the vessel is weakened and apt for dilatation.

Since the middle coat around these spots of thickening is generally more or less in a state of fatty degeneration, and since the parts, altered as above described, are inelastic, it follows that unusual strain falls upon the portions which have not become hard and rigid; moreover, the roughening of the interior of the artery, obstructing the blood-current, increases the pressure on those parts of the vascular walls which are not the seat of the thickening. Calcification hardens and protects the vessel against dilatation at the converted spot, but its rigidity increases the strain on such parts of the walls as are still dilatable. If either or all of these forms of thickening and encroachment on the arterial walls occur near the heart, as in the first part of the aorta, such an impediment to the course of the circulation is produced that hypertrophy of the left ventricle usually follows, thus increasing the tendency to aneurism by adding force to the blood-current.

We have yet to consider what primary cause can originate the chronic endarteritis leading to these changes. It must be observed that it is not a disease of early life; we do not meet with it before the age of thirty, seldom before that of forty-five. Congenital or acquired syphilis, tuberculosis, rheumatism, alcoholism, do not seem capable of causing during youth the endarteritis which ends in atheromatous thickening.[1] Another point to be observed is the absence, with very rare exceptions, of atheromatous thickening in the venous system, a fact which some writers have regarded as supporting the view that the malady originated in a deposit from arterial blood. But it should be recollected that the pulmonary veins which contain red blood are at least as free from atheroma as the arteries of like name which contain dark blood; also it should be remarked that the tunics of the venous system are differently constituted; nor are they exposed to the same amount of pressure from within.

Syphilis.—A certain number of writers, chiefly military surgeons, consider atheroma and aneurism essentially syphilitic, and this view is strongly upheld by Dr. Aitken,[2] who says: "I believe that a large proportion of cases of inflammation of the large vessels ending in atheroma are of syphilitic origin," and doubtless some records of military surgery seem at first sight to support this idea. Thus Mr. Welch[3] relates that of thirty-four cases of aneurism in the army, seventeen occurred in syphilitic soldiers; but such numbers prove nothing, unless it be known what proportion of the regiments from which these men came were similarly affected. Mr. Lawson, in his statistics,[4] shows that aneurism is more frequent in the military than in the civil population; but here again the other circumstances of military life are not known or noticed. Mr. Myers[5] has very ably sifted the statistic numbers, and the inference drawn from them, thus: Syphilis is about equally prevalent in the army and in the navy, but for aneurism the numbers for four years are:—

| | Army strength. | Aneurism per 1000. | Navy strength. | Aneurism per 1000. |
|---|---|---|---|---|
| 1862 . . . . | 49,332 | .28 | 58,870 | .11 |
| 1863 . . . . | 44,291 | .47 | 54,090 | .05 |
| 1864 . . . . | 40,539 | .37 | 53,000 | .18 |
| 1865 . . . . | 42,228 | .35 | 51,210 | .09 |

Both sets of men are subject to much the same influences of climate—both have to undergo considerable bodily exertion. But the sailor wears a loose overshirt, with no constriction around the neck; the soldier a tightly-fitting coat with a tight collar, obstructing circulation in the axillaries and carotids. The soldier suffers especially from aortic aneurism.

Moreover, it is to be observed that we frequently encounter in the post-mortem room the bodies of children or young persons in an advanced condition of syphilis, whose viscera may be more or less studded with gummata, but atheroma is quite as rare with them as with healthy individuals, nor does it begin at an earlier period of life in the one set than in the other. Four cases

[1] It should be here remarked that certain aneurisms are marked with these thickenings, even though in comparatively youthful subjects; but the stretching or tearing that the vascular tunics must, in order to permit of aneurism, undergo is, in all probability, the direct cause of localized endarteritis, since when we find on an aneurism, especially if the patient be young, one or two such nodules, while the rest of the vascular system is healthy, we are not to conclude that the atheroma produced the aneurism; the sequence of causality is probably exactly the reverse.

[2] Science and Practice of Medicine, vol. ii. p. 630.

[3] Med.-Chirurg. Trans., vol. lix. p. 59.

[4] Transactions of Army Medical Department, 1866.

[5] Pathological Transactions, vol. xx. p. 134.

of very early aneurism are recorded,[1] but not one of the patients is described as having been affected by syphilis. In ordinary hospital and civil practice, we find that, while aneurism is undoubtedly less common in females than in males, syphilis offers no such great sexual disparity; nor have I found that prostitutes are peculiarly liable to atheroma or to aneurism—certainly not at all more so than might be expected, seeing that persons of that class are usually somewhat intemperate, and exposed to rough usage from blows, etc.

If we examine the records of the London Pathological Society, we find that during the 10 years, from 1871 to 1880 inclusive, 68 cases of aneurism were recorded. Of these—

In 23 syphilis is not mentioned,
" 35 " is stated to have been absent,
" 8 " is stated to have been acquired,
1 patient is said to have had soft chancre,
1 case is mentioned as uncertain.

In those of the first class, the history of all illnesses being given, the non-mention of syphilis is significant. The patients are described as having been healthy in 6 cases; as drunkards in 3; the aneurism is ascribed to sprain in 4.

In the histories of the second class, drink is recorded in 4; acute rheumatism (3 times in 1 patient) in 3; blows or sprains in 5. In the case of the patient to whom soft chancre is ascribed, no secondary marks were recorded during life or after death. The one whose infection is called uncertain, was a confirmed drunkard. Of the 8 who are said to have had syphilis, 1 had chancre as a lad and died at 29, no secondary marks being recorded, a drunkard with cirrhosis of the liver; 1 had chancre 16 years before, no secondaries recorded; 1 had scars of buboes, absence of secondaries mentioned; 1 is stated to have had secondary and tertiary symptoms; 1 is recorded by Dr. Mohammed, in the volume for 1878, as having exhibited in the post-mortem room secondary lesions.

Now I am aware of the little weight that can as a rule be attached to negative evidence; but it can hardly be supposed that in 59 cases out of 68, syphilitic degenerations of internal organs would, if present, be overlooked, save in a single instance. This negative testimony shows, at all events, the absence of positive evidence. Yet it is not my intention to deny the existence of a syphilitic arterial degeneration—indeed it is certain that such a thing exists. Dr. Wilks[2] was, I believe, the first to point out that such changes probably take place, but he shows his great pathological insight by expressly stating that, "If it be true that the bloodvessels are liable to be affected with the syphilitie taint, it will probably be found that the change is not of the atheromatous kind, but rather of the fibrous character exemplified by the thickening of the coats of the vessel, and the proportional diminution of their calibre." Dr. Clifford Allbutt[3] points out that syphilitic arterial thickening is much more rapid than atheroma, and Dr. Moxon[4] also notes many points of difference. I must also point to the fact that while atheroma has its favorite seat in the aorta and large vessels, syphilitic arterial disease affects smaller branches, chiefly those not larger than the temporal over the squamous bone, or the ulnar in the palm—rarely vessels as big as the radial at the wrist; that it has a marked proclivity for the cerebral branches of the internal carotid; that, unlike atheroma, it does not, in the initial stage, enlarge the lumen of the vessel, and at no stage increases its length so as to make it wavy; its first attack is closer to the endothelium, is, in fact, in the deeper layers of that

[1] Hutchinson, Path. Trans., 1854; Armitage, ibid., 1858; Syme, Edinburgh Monthly, 1844; Smith, British Medical Journal, vol. i., 1867.

[2] Guy's Hospital Reports, 1863, p. 45.

[3] St. George's Hospital Reports, vol. iii. p. 55.

[4] Op. cit.

structure—its tendency is towards obliteration of the vessel by encroachment on its lumen. As to its microscopical characters, I would chiefly refer to the presence of giant cells, with a large quantity of round cells,[1] and to the after striation and fibrillation of the syphilitic growths. Indeed, syphilis as it affects these vessels is in nearly every point, if carefully examined microscopically, macroscopically, and clinically, different from atheroma.

I think, therefore, we must conclude that there is no clinical or anatomical evidence to show that systemic vessels, large enough to permit the formation of an important aneurism, are ever the subject of syphilitic affection. To refute the somewhat widely accepted hypothesis that aneurism is of syphilitic origin, would require a vast number of negations, each one of which might be answered by asserting that the examination had not been sufficiently careful or scientific. But it must be pointed out that on him who makes the assertion, lies the burden of its proof, or at least of its support with some array of sufficiently sifted facts, such as are at present entirely wanting.[2]

Rheumatism occupies a very different ground. Inflammation of parts of the circulatory system is a well known accompaniment of that condition, and a large number of aneurismal cases have suffered from acute, others from subacute rheumatism. It certainly appears likely that a disease which produces endocarditis may also cause endarteritis.

Alcoholism has, I believe from my own observations, great influence on the production of atheroma; especially does the drinking of raw or slightly diluted spirits tend to this condition; probably the circulation of alcohol and fusel oil in the vessels irritates the inner coats. The frequency of aneurism in Ireland, where this unfortunate habit prevails, may to some extent support this view. Excess in more largely diluted spirits leads, as we know, to non-inflammatory fatty degenerations of various tissues, among them to that condition of the middle coat mentioned a few pages ago, on which the aneurismal diathesis depends.

I believe, though I cannot prove, that aneurism, when due to a systemic condition at all, is more frequently owing to the abuse of alcohol, or to rheumatism, or to both, than to any other cause. The frequency of aneurism in England, so much greater than in France or Germany, may be owing in part to the dampness of the climate, and in part to the unfortunate national love of strong liquor. It must be added that in both the above continental states the tendency to aneurism is greatly increasing.

## Structure of an Aneurism.

Contents.—The contents of an aneurismal sac always consist of blood; but this blood is not always in the same condition, for it may be entirely fluid, as, indeed, is generally the case in fusiform aneurisms; or, it may be loosely coagulated, barely consistent, like the ordinary clot formed of blood poured from a wound—this sort of semi-solidified coagulum was named by Broca "*passive clot;*" or, again, the cavity may be lined partially or throughout by firm, buff-colored fibrin, from which the globules have been extruded. Most sacculated aneurisms are thus, as it were, padded—at least in those

[1] Heubner, Die luetische Erkrankung der Hirnarterien, 1874, S. 127. See also, Lanceraux, Traité historique et pratique de la Syphilis; Langhaus, in Virchow's Archiv, Bd. xxxvi., S. 187, and a host of others.

[2] Many morbid anatomists assume syphilis from the presence of atheroma, and then formulate the contention that atheroma is syphilitic.

parts which lie out of the most rapid current; hence, those with small mouths have *cæteris paribus* the most of such lining, which, being deposited from the blood by successive acts of solidification,[1] is laminated and marked by concentric lines. Broca called this material "*active clot.*" We shall see, by and by, that aneurisms may by the accumulation of such coagulum be spontaneously cured; that upon the induction of such accumulation our successful treatment is founded; and that, in certain cases, the choice of methods is to be guided by an estimate of the quantity of such clot which nature has already deposited in the sac. Moreover, it is noteworthy that a lining of firm, resilient fibrin acts against the force of the blood as a species of buffer, protecting the proper wall of the tumor, and preventing, according to its thickness, further distension and rupture. All aneurisms which are thus lined, and in so far protected, progress—if nothing modify the conditions—more slowly than those in which no active clot is formed.

The Sac of an Aneurism may consist entirely of the arterial coats, all three being present in the fusiform variety, unless it be unusually large, while in the sacculated, unless merely incipient, both the inner and middle coats are deficient throughout a large part of the tumor. In many cases, however, all three coats have over a certain extent given way. The sac is then formed in part by laminated fibrin, in part by surrounding structures. Many thoracic aneurisms, which press against the parietes of the cavity, have for part of their sac the spine, the sternum, the ribs, or their cartilages. The stretched arterial tunics which enter into the formation of the sac are, in large aneurisms, generally atheromatous, calcareous, or both. Sometimes even patches of true bone are found, but this is rare.

## Symptoms of Aneurism.

The *symptoms of aneurism* are some of them intrinsic, or direct; others extrinsic, or indirect.

*Intrinsic Symptoms* are inherent qualities of the aneurism itself. If disease were strictly logical, we might describe them as necessary and integral parts of the malady, but since the body is not an exact machine, one or another of them may be absent.

*Extrinsic Symptoms* are due to the influence of the aneurism on surrounding parts, and are chiefly referable to the effects of mechanical pressure. They vary, therefore, with the function of the part compressed. In certain localities the intrinsic signs are not to be detected, or are greatly obscured by inclusion of the tumor within the more or less resistent walls of some cavity. In such cases the extrinsic signs may enable the surgeon to infer the presence of aneurism.[2]

Pulsation.—The most marked and characteristic sign of an aneurism, situated within reach of palpation, is the presence in the course of an artery of a pulsatile tumor. If the form of the swelling be elongated, and the throb extend over a narrowing space and with diminishing force, for a considerable distance up and down the limb, the aneurism is of the fusiform variety; if the tumor be round or oval, and clearly defined from its surroundings, while

[1] The theory that this clot is a secretion from the vessels is sufficiently disproved by observing that in most cases it barely adheres to the inner wall of the sac.

[2] Until lately, internal aneurisms, save a few abdominal cases, interested only the physician; but recent advances, due chiefly to Dr. Cockle, Mr. Heath, Mr. Holmes, and myself, have placed thoracic aneurism within the pale of surgical treatment.

the separate beat of the artery immediately above and below cannot be verified, the sacculated form of aneurism may be suspected. I say suspected, because every tumor which pulsates is not an aneurism; the pulsation must be of that peculiar quality which we term expansile—that is to say, when the swelling is grasped in the fingers of one or both hands, the beat must seem to drive them apart; it must not merely lift the hand as by a wave propelled from below, but the swelling must be felt to dilate and enlarge with every beat of the heart. If the aneurism be so situated that the artery above it can be compressed, pulsation ceases when such presence is exercised, and the tumor becomes smaller and flaccid—may, indeed, almost entirely disappear; by manipulation, unless it contain a large quantity of clot, the sac may be still further emptied.[1] The surgeon should now mark well the size of the enlargement, and let the pressure above be suddenly removed, when he will see or feel the more or less abrupt restoration of size and refilling of the sac. In some cases, that is, when the aneurism has a large mouth, this enlargement is very sudden—with one beat of the heart the whole sac is filled as by a leap or plunge; when the mouth is small, several pulsations, perfectly visible and distinct, are required to fill the tumor; but I would draw especial attention to the fact that the initial pulsations are as strong, or very nearly so, as the usual throbs of the tumor. They do not begin weak and increase slowly. Sometimes in aneurisms whose walls are thin and are not thickly lined by clot, compression on the vessel below will cause a certain slight, and almost momentary, enlargement. This symptom, when present, is a useful aid to diagnosis—its absence predicates nothing as to the nature of the malady. Generally, the vessels beyond an aneurism beat less forcibly than in the normal state; less forcibly, for instance, than those of the other limb. When vessels leading to the arm, or even to the head, are affected, this symptom is more easily appreciated than when those leading to the lower limbs are involved, since the arteries are better placed for feeling the pulse; we may, in the case of the arm, gain greater accuracy by the employment of the sphygmograph.

Bruit.—A symptom which is often present, though frequently absent, is a sound at each pulsation. It varies greatly in quality and character, being in some cases a mere thrill or purr, in others an almost flute-like noise, a creak, a rasping or a sawing sound. It appears that its characters, and even its existence, depend upon the size, shape, and situation of the sac's mouth, and perhaps also in part on the nature of the surroundings. Abdominal and thoracic aneurisms, for instance, are rarely accompanied by any bruit.[2]

This sound, when present, is very conclusive evidence of the nature of the disease,[3] but its absence in no way negatives the presence of an aneurism. I have known several aneurisms which, during some part of their progress, emitted well-marked sounds, and at other stages were quite noiseless; as also many that have been silent throughout. These intrinsic symptoms of aneurism can be verified with ease when the disease is external, but if it be internal many of them cannot be made out until the tumor has attained a considerable size—more or less, according to situation—that is to say, until it has to a certain degree approached the parietes. A tumor, for instance, on the third part

[1] This method of research should be very cautiously, if at all, employed, since the clot which may have formed is liable to displacement, when its beneficial action would be prevented, and perhaps danger of embolism evoked.

[2] A peculiarity of sound to be noted hereafter is very generally observable when the disease is intrathoracic—viz., the second sound of the heart is abnormally loud over the tumor, while no such exaggeration is perceptible over the heart itself.

[3] A few non-aneurismal tumors occasionally emit a distinct bruit, as will be noted immediately.

of the aortic arch, growing forward, must be very big before it can be felt to pulsate on the front of the chest, while an aneurism of the first part of the aorta, increasing in the same direction, will pulsate through the costal cartilages very much earlier. So, also, an aneurism arising between the pillars of the diaphragm, cannot be detected by clearly-marked pulsation as early as one on a level with the third or fourth lumbar vertebra. Nor can at any time the tumor be grasped or manipulated, so as to verify the expansile beat above described. The existence of certain aneurisms, especially within the thorax, may often be suspected, and sometimes clearly diagnosed by a correlation of certain symptoms, effects of pressure, etc., before any pulsation can be distinctly verified. But to this subject we must return.

Pressure Symptoms.—The symptoms which I have classed together under the name extrinsic, are those which are produced on the neighboring parts by pressure, and it seems that in this pressure there is something peculiar, as we do not see the same intense effects produced by other tumors; probably the special quality lies in the beat, that is to say, in the intermittent nature of the force. We find, therefore, that when an aneurism impinges upon bone, it effects its absorption sometimes with surprising rapidity; it also displaces and absorbs solid soft tissues very quickly; if it come in contact with nerves, it flattens them out and causes troubles according to their function; and if in apposition with a tube, occlusion takes place: thus, for instance, veins, trachea, bronchi, œsophagus, and ducts are closed by the growth. Hence it will be evident that the pressure symptoms of aneurism must vary with the locality; many of them will require careful study in connection with aneurisms of special arteries, but we may here describe the more common of such symptoms as they occur in the limbs.

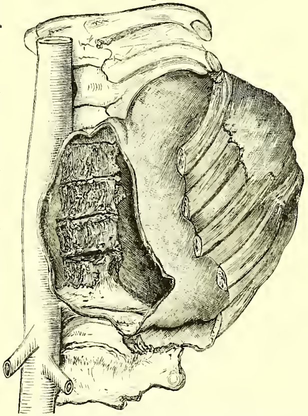
*Enlargement of veins* and *œdema* below the seat of disease are common in aneurisms of such arteries as lie close to veins. Hence different localities exhibit these symptoms variously as to their time of appearance and their degree; not only so, but aneurism of an artery will in one case be accompanied by early and strongly marked œdema, while in another case the symptom is of later occurrence and never becomes prominent. For instance, innominate aneurism may be primarily manifested by œdema of the left supraclavicular region and left arm—swelling of the right side being late or never occurring; in other cases, the œdema will manifest itself first and chiefly on the right side. Certain subclavian aneurisms will be chiefly evidenced by swelling of the same side of the neck, and, if on the right side, by teasing cough or aphonia, while the first symptom in other cases is agonizing, remittent pain running down the arm. When the disease affects either common or external iliac, or common femoral, œdema of the leg and thigh is very nearly always an early and well-marked symptom, while aneurism of the aorta, just above its bifurcation, may produce the same result in both lower extremities. Œdema, in any of these diseases, may be the first thing which attracts the attention of the patient. Thus in 1867, a man came to me complaining of nothing but a swelled leg and thigh, which he said felt heavy and stiff, but were not painful. He had no idea whatever that he had any severe malady, attributing the swelling to a severe catarrh which he had lately caught; I found, just beneath Poupart's ligament, an aneurism about the size of a hen's egg.

When a nerve is so placed as to cross or lie upon the tumor, it usually becomes flattened and thin; the pressure is rarely sufficient to entirely close the tubules, but often produces *numbness*, and some degree of *anæsthesia;* the sense of *weakness*, so often mentioned by patients, is doubtless often due to similar mechanical effects on the motor portions of the nerve. This partial closure and stretching of the cords is accompanied by intense shooting and

stabbing *pains*, which may first of all call the patient's, and so the surgeon's attention to the part. Such early, and, if I may so call it, primary manifestation of pain, is most common in aneurism of the last part of the subclavian and first of the axillary artery; sometimes it is early in popliteal aneurism—when, namely, the tumor springs from the superficial wall of the artery and grows backwards. The *motor function* of nerves may also be greatly affected, or indeed altogether destroyed; this is most strongly exemplified, as we shall see in the sequel, in certain aneurisms of the upper part of the thorax and lower part of the neck, which paralyze partially or totally a vocal cord.

We have seen that one of the most remarkable consequences of aneurism is the production by its pressure of rapid *absorption*, usually without suppuration, of bone and of cartilages. Erosion of the vertebræ is a common result of aneurism of the descending aorta; the outer case, that is, the harder part of the bone resists the rodent action for a certain time, but when this is once broken through, absorption is very quick; aneurisms have more than once, after eating away the vertebral body and the adjacent intervertebral substance, burst into the spinal canal. But most limb-bones, being more dense, are with more difficulty attacked; hence, in such a malady as subclavian or popliteal aneurism, the clavicle or femur is less often found excavated. Sternum, ribs, and costal cartilages are frequently eroded over the space on which a thoracic aneurism is pressing. The pressure and caries produce pains which are often very severe, and of a character which must be distinguished from those of nerve pressure; they are generally more distinctly localized, and are burning and aching.

Fig. 533.



Aneurism of the thoracic aorta, eroding vertebræ and ribs; front of sac removed to show vertebral bodies. (From a preparation in Charing Cross Hospital Museum.)

## Differential Diagnosis.

Both intrinsic and extrinsic symptoms of aneurism have a certain margin of ambiguity which care in examination must eliminate. I would most especially insist on this element of care. Certain fortunately rare cases, even of limb aneurism, present difficulties which may baffle the most searching and skilful investigation; but by far, by very far, the larger number of disastrous mistakes which have been made in dealing with aneurisms, have been due to insufficient caution, as when, for instance, a surgeon, with misplaced self-confidence, plunges his knife into a painful, fluctuating, and apparently to his hasty palpation, a nonpulsatile tumor, even though it may lie close to a large artery. Care and caution in such cases are the points upon which I would lay the greatest stress; no swelling in the course of, or over, a large artery ought to be opened without a previous thorough and searching investigation.

The causes of error fall naturally into two categories, for there are,

I. *Pulsatile tumors that are not aneurisms*, and

II. *Aneurisms that are not pulsatile.*

I. Pulsatile Tumors that are not Aneurisms.—Any tumor, fluid or solid, if placed immediately over a large artery, may have pulsation communicated to it. An *abscess*, well encysted and firmly bound down by fascia upon such a vessel, may pulsate in a very deceptive manner, and many mistakes which have been made under such circumstances might be collected. They appear to have arisen less frequently from the inherent difficulties of the case than from the habit of accepting one or two symptoms as conclusive in diagnosis. The presence of inflammation, the appearance of pointing, the absence of pulsation, do not, even when taken altogether, prove a swelling to be an abscess. As, for instance, in the case which Pirogoff records,[1] with a frankness that does him honor: He was, on his return from a long and fatiguing journey, called to a man who was in severe pain from an inflammation, apparently a suppurating phlegmon, of the leg; immediate relief from his suffering was the patient's only desire. The case seemed to the overtired Pirogoff perfectly clear; he plunged a scalpel into the swelling, and was informed of his error by a gush of arterial blood. Richet[2] was on the point of opening what seemed to him an axillary abscess, when he fortunately felt a thrill, and on further examination detected bruit. The case was one of axillary aneurism. Inflamed aneurisms, when more deeply placed, are more difficult of diagnosis; as, for instance, in the case of Bergmann, who opened what appeared to be a "phlegmonous angina." No sudden escape of blood ensued, but the patient died of asphyxia, when the disease was found to be aneurism of the internal carotid artery.[3] Dr. Stephen Smith,[4] in confessing an error of his own and recording one or two others, comments on the difficulties of diagnosis, which, I think, he somewhat exaggerates, by showing that no *one* symptom of aneurism, as given in surgical works, is pathognomonic. I certainly shall not dispute that contention; it is the collective evidence of all symptoms that must guide the verdict.[5]

Now an abscess firmly bound down upon an artery and inclosed in a tough wall, resembles, in those physical points with which we have to do, a *cyst*—such a cyst, for instance, as may arise in the popliteal space in connection with the knee-joint or with a flexor sheath. All three diseases, aneurism, abscess, and cyst, may present a globular or ovoid pulsatile tumor, forming rapidly after over-exertion, and two of them (cyst and aneurism) may be preceded by the sense of something breaking or giving way; they may all three be devoid of bruit. But the pulsation of the two latter diseases is not distensile, as is that of aneurism; their throb is diminished on flexing the limb and relaxing the fascia; and in this posture they may sometimes be lifted away from the artery, when pulsation ceases entirely or in great part. Often, when the fascia is moderately tense, the beat of the tumor can be detected as being most marked along a line corresponding to the direction and place of the artery.[6] The tumor does not diminish and increase on compression and release of the vessel above. In some cases such a cyst may be emptied by

[1] Klinische Chirurgie, S. 95.

[2] Gazette des Hôpitaux, 1879.

[3] Zeitschrift der Chirurgie, Bd. xiv. Heft. 1 and 2, S. 2.

[4] American Journal of Medical Sciences, April 1873.

[5] The point on which Dr. Smith lays most stress as most diagnostic, is the past history of the patient, more especially the sense of something having given way. I cannot say that I have found patients' accounts of former sensations at all reliable; they are often taught them by their questioners. Mr. Holmes (St. George's Hospital Reports, 1874, p. 177), in commenting upon this paper, brings very much into prominence, as the one reliable symptom, the bruit. I have seen so many aneurisms without bruit, while so many non-aneurismal tumors with bruit are recorded, that this symptom appears to me one of the least valuable; certainly its absence indicates very little. But especially valuable, when anatomical situation permits the test, is diminution in the size of the tumor on pressing the artery above, and its rapid increase when the vessel is released.

[6] An aneurism springing from the front of the artery and growing towards the bone may present this linear pulsation, but it is increased on extension of the limb.

pressing the fluid into the joint or other cavity with which it, perhaps, may still be connected; but this will occur as quickly when the artery is at liberty as when it is compressed, and the refilling will be slow and equable, not the sudden rebound of a replenished aneurismal sac.

Case VI.—In the year 1879, a patient was sent to me, by a very excellent provincial surgeon, with a supposed popliteal aneurism which had made its appearance after an unusually long walk. By the light of the symptoms above referred to, I made it out to be a synovial cyst communicating with the knee-joint. Both the sensation of something having given way, and the power of emptying the tumor, followed by slow refilling, existed.

*Cysts of the neck*, situated over the carotid, are some of them easy, others difficult, of diagnosis. The ordinary hydrocele of the neck, in its mode of growth and pulsation, in the ease with which it may (unless very large) be lifted from the vessel, and often in its translucency, is quite unlike aneurism. Cysts connected with the thyroid more closely simulate aneurisms in their physical properties; but I have never seen such a tumor which did not rise with the trachea when the patient swallowed; and never a carotid aneurism which did so.

*Hæmatocele of the neck*, when it pulsates, is often excessively difficult of diagnosis, especially if it has originated in the rupture of some vein just before it enters the jugular; for such a cyst cannot be lifted up from underlying parts. Nevertheless, the linear character, or at least the non-uniformity of pulsation over the whole mass; its position, generally outside of the usual place of aneurism; the fact that it remains of the same size if the artery be compressed below, or, when that is impossible, above; and the fact that pressing the tumor back towards the spine increases the pulsation,[1] mark pretty clearly the probable nature of the case.

Case VII.—In March, 1876, a man, aged 43, came under my care into Charing Cross Hospital, with an inflamed, pulsatile tumor of the neck, situated on a level with and a little outside of the bifurcation of the carotid. The man was among other things a prize-fighter, and had often received blows upon the front of the neck. The tumor had made its first appearance, small and painless, twenty-one months previously. He asserted that six months before he could see it beat more plainly than on his admission.

The pulsation was not uniform, being more marked on the inner, and less on the outer part of the tumor; it was increased on pressing the lump backward towards the spine, and then was almost or quite uniform. Compression of the carotid below seemed to one of my colleagues to render the tumor somewhat flaccid; this was to me very doubtful. The part was inflamed and very painful, the skin over it red.

In consultation, we agreed to pass in a very fine exploratory trocar; the result was the escape of dark, grumous blood, mixed with what seemed to be decomposed pus; but the instrument was immediately plugged by shreds, and only a drop or two was obtained. Different opinions were formed: one surgeon thought that the tumor was a consolidated aneurism, now suppurating; one declined to decide; while I believed it to be a suppurating hæmatocele. The man was ill, with very high temperature; and seeing the danger of blood-poisoning, I determined to take upon myself all risks. Having prepared everything for tying the carotid above and below, if necessary, and for compression on Chassaignac's tubercle, I opened the sac just enough to admit my forefinger. Detritus of old clots, pus, and purple-brown blood, all mixed together, followed the first incision, but my finger corked the wound, and at that time very little escaped. I broke up all soft and flocculent tissue, but could find no opening as into a vessel. Mr. Hird, at my request, now commanded the artery. I removed my finger and let the ill-odorous, grumous fluid escape, and syringed out the cavity till it was quite clean; a drop or two of bright-colored blood came away. Very slowly and gently the pressure on the carotid

[1] A pretty well-marked, but transient, increase in size and tenseness follows such distal compression, if the tumor be aneurism.

was removed, but to my relief no hemorrhage occurred. During the next week every precaution to meet such an event was adopted, but the emergency never arose. The man suffered a slight pyæmic attack, which, indeed, had existed before the operation; but he recovered without any local disaster.

*Cyst or Abscess coexisting with Aneurism.*—A cyst may, as a great rarity, lie over and conceal an aneurism; or, more commonly, an abscess may arise around such a tumor, so that the pus bathes the outer surface of the sac. Great embarrassment of diagnosis must, especially if no bruit exist, be thus produced. Yet a certain flaccidity follows compression on the artery above, and deep palpation will generally detect pulsation. Dr. Haens, as quoted by Dr. Stephen Smith, opened an abscess of this sort; eight days afterwards the aneurism burst, and hemorrhage ensued. Mistake could hardly be imputed to the surgeon; the diagnosis of abscess was correct, but the whole disease was not made out.[1] When an abscess opens into an aneurism (the same thing may happen to a cyst), or into a previously healthy artery, the wall of the abscess becomes the aneurismal sac; the symptoms of abscess and of aneurism become combined. Bruit will almost certainly be present, and flaccidity must surely, in all cases, be produced by commanding the circulation above; it is hardly possible that both these symptoms should be absent.

Let me again especially point out that the presence of fluctuation, inflammation, and redness of the skin, with an appearance of pointing, in no wise negative the presence of aneurism. Where the slightest doubt exists it is better to temporize; a few days often bring a difference that clears up the obscurity.

*Solid tumors overlying an artery* often closely resemble aneurism. Dr. Erskine Mason records an error made by himself and many consultants, in considering a sarcoma in the popliteal space to be an aneurism,[2] while Dr. Dunning made the opposite error of cutting into an aneurism (popliteal) which was supposed to be a sarcoma.[3] Similar errors have been made by English and Continental surgeons; it will be perceived, therefore, that sometimes the simulation of one disease by the other must be very close.[4]

Most sarcomatous, malignant, and cystic tumors are less definite in outline than aneurism, less even on the surface, and less globular. The bruit, if any exist, is not the peculiar whirr or blowing of an aneurism, nor is the alternation of loudness and softness with systole and diastole as well marked as in that affection; it is rather a confused, indefinite, and nearly equable murmur or rushing sound, the intensity of which varies at different parts of the tumor.[5] Many of these tumors, those, namely, that are very vascular, or that contain blood-cysts, become smaller and softer when the artery above is compressed, but less rapidly than an aneurism, and, on releasing the vessel, the refilling is not with such a sudden bound, nor does the pulsation recommence at once with the same —its usual—degree of force, but, beginning with less, attains in a given number of beats its accustomed intensity. The pulsation varies in strength in different

[1] An additional reason for caution in dealing with fluid tumors over an artery.

[2] Dr. Mason especially says, "On applying the stethoscope there is heard a loud and distinct bruit," but he does not say if the test by emptying and refilling of the sac was attempted. (American Journal of the Medical Sciences, Jan. 1877.)

[3] New York Medical Record, August 5, 1876.

[4] Jessop (Lancet, Jan. 4, 1873) tied the femoral artery for a supposed aneurism, occupying the lower two-thirds of the thigh. The pulsation was weak, and ceased on compressing the artery above, but the tumor did not diminish in size. Thirteen weeks after, gangrene supervened; in the sixteenth week she died. The tumor was a fibroma.

[5] Mr. Holmes remarks (St. George's Hospital Reports, 1874), that the amount of sound is not commensurate with the size of the tumor; but I am not aware that in aneurism the loudness of sound depends at all on the size of the tumor; very large aneurisms often emit a verv gentle bruit, or none at all.

parts of the tumor, and is less expansile than that of an aneurism: it is not so clearly a centrifugal distension, but more like an upheaval of the whole mass by a wave from beneath. In these cases an exploratory puncture helps hardly at all, since sarcomas, cystic growths, and aneurisms, may all furnish blood. This blood, or any shreds in it or on the nozzle of the exploring canula, should be investigated, since the elements of a neoplasm might be found. Or, if doubts were strong, a very small tissue-extractor might be employed. If the disease be in the abdomen or iliac fossa, the urinary sediments should be subjected to the microscope, since in Mr. Moore's case[1] the urine contained cancer elements. Difficulties in the diagnosis of abdominal aneurism will be referred to hereafter, but a case may be here mentioned:—

Case VIII.—A woman, aged 42, was, in the early part of 1869, under the care of Dr. Head, and dying of Bright's disease. She was also supposed to have an abdominal aneurism, which occupied a space two inches below the xiphoid cartilage; to the right, reached the level of the umbilicus; and to the left, where was the chief bulk of the tumor, ran below that spot. I often, for the sake of study, compared this case with one of abdominal aneurism in a neighboring bed. The expansile heave of both tumors was identical; neither had any bruit. The woman succumbed to her kidney disease in five weeks. It was then found that the supposed aneurism was an abnormal lobe of the liver, which lay on and almost encircled the aorta, and, coming forward, pulsated against the abdominal wall.

Malignant Tumors, especially of Bone.—Even more difficulty is encountered when the diagnosis rests between an aneurism and certain tumors which possess an inherent pulsation of their own. The coincidence that such growths should be situated close to large arteries, is less unusual than might at first glance be supposed, since those trunks lie generally on the flexor side of limbs, coursing through spaces filled with lax areolar tissue and with lymphatic glands—with, in fact, that sort of structure which is commonly the seat of cystic and malignant growths. The diagnosis between aneurisms and certain forms of cavernous or erectile tumors, myeloid growths, soft, spindle-celled sarcomas, or encephaloid cancers, especially if highly vascular or studded with blood-cysts having very intimate relationships with the vessels, is exceedingly difficult, and depends upon certain differences in the mode of pulsation and of emptying and refilling, in consistence, and in the character and amount of sound, which can only be detected by very practised persons, and, in some cases, if the disease be deep-seated, not even by the most skilful. Errors have occurred in the practice of very eminent men, even when others of equal position have been called in consultation. I need hardly quote the well-known paper by Mr. Moore,[2] on a case of supposed aneurism of the common iliac, which turned out to be encephaloid; or the case of Sir James Paget, who cut down on the external iliac with the intention of tying that vessel if the doubtful tumor should turn out to be an aneurism, the operation being abandoned, since the growth seemed to be a cancer. The man died of hemorrhage from the disease, which, on post-mortem examination, was found to have been after all an aneurism.

The difficulty of diagnosis is increased by deep position of the disease, and by hard consistence of the parts from which it springs or by which it is surrounded; for this reason, as also from similitude, the pulsatile tumor of bone, especially if deep, as in the iliac fossa, is one of the diseases liable to be mistaken for aneurism. But, besides the character of the pulsation and bruit being, as above specified, rather different from that of aneurism, certain changes in the form of the affected bone may, on careful examination, usually be

[1] Med.-Chir. Trans., vol. xxxv. p. 459. [2] Ibid., p. 468.

detected. Its outer layer expands into a case for the base of, or may send out spiculæ and ridges into, the mass; or an outlying spur of the tumor may eat away a portion of the bone, and be pulseless; or, again, the tumor may occupy both faces of a flat bone, such as the ilium, and may thus betray its real nature.[1]

II. Aneurisms which do not pulsate present to the surgeon very difficult problems. Probably aneurisms proper (that is, not cirsoid aneurisms, nor wounded arteries) only cease to beat under three conditions: (1) Consolidation, involving the part of the artery implicated; (2) Rupture and diffusion; (3) Compression, by the sac, of the artery above.[2] That errors may arise is shown by the case quoted by Mr. Erichsen, of an amputation at the thigh for supposed tumor, the disease turning out to be a popliteal aneurism spontaneously cured.[3] Nor do I know of any positive signs by which to distinguish between a solidified aneurism and other hard tumors. The history of the case and the age of the patient must be taken into account, but the great aid to diagnosis will be the more or less globular form of the tumor, its isolation from adjacent parts, and the fact that it does not increase (if really solid), but rather decreases. Certainly, in such a case, no mutilating operation should be performed, particularly if the lump were seated near one of those arteries known to be eminently prone to aneurism.

*Ruptured Aneurisms.*—An aneurism which has burst widely and largely, filling the limb and distending the fascia with considerable blood-effusion, is hardly to be mistaken for any other condition. But if the sac has given way to a very slight extent, after the manner to be presently described, the greatest embarrassment of diagnosis may arise, for the effused blood may not stain the skin by showing through it, or by producing ecchymosis; indeed, the surface is often unusually white, while the superficial veins, the main one being compressed, mark themselves out in a distinct meshwork as they do in cases of deep, rapidly growing tumors. Moreover, the blood, being slowly effused, partially coagulates, covering the aneurism and percolating the tissues, so that the swelling has neither definition nor pulsation; and as the clotting is generally irregularly disposed here and there among the tissues, an uneven consistence and a nodular surface are produced. Position, too, may cause part of the effused blood to gravitate to some distance, so that the tumor appears to spring from some point a long way from the artery. The pulse beyond is usually weakened, as is common in aneurism, but this, in the cases we are considering, is probably due to pressure of the tumor, which commonly grows either equably or, not unfrequently, remittently.

Judging from the cases of this condition which I have seen and very carefully studied, the correct diagnosis is only to be made out from the history, when that is sufficiently clear; a reference to the medical man who may have seen and treated the patient before such obscurity arose, will always be desirable. Fortunately, this embarrassing condition of the disease is rare; an error, unless it lead to free incision, is not of vital importance, since if the

[1] A case of pulsatile tumor on the head came under the care of Bardeleben in 1876. It must have presented unusual features, since that surgeon diagnosed it as an aneurism of the middle meningeal artery. The matter attracted considerable attention in Germany, as so rare an affection was likely to do. Several operations were performed, including ligation of the internal carotid. The child was not benefited, but lived for some years. After death the tumor was examined, among others by Virchow; it was a large spindle-celled sarcoma growing from the diploe. (Zeitschrift der Chirurgie, 1877.)

[2] This last must be rare. I give it on the authority of Pirogoff. If such a condition does exist, it must lead rapidly to spontaneous cure.

[3] If one may judge from the illustration (Science and Art of Surgery, vol. ii. p. 291), the error in that case must have been a difficult one to make.

aneurism arise on the trunk, quietude and rest will in all probability be the treatment adopted; if on a limb, amputation will be resorted to; and this is the course which, if such an aneurism were diagnosed, would be the proper resource, as more likely to save life than any other course. A certain number of errors have been made, and doubtless will be made again. Thus, in 1866, my late colleague, Mr. Hancock, amputated the thigh of a man for supposed sarcoma of the popliteal space. The disease proved to be a ruptured aneurism in the above condition. Some of the effused blood was solid, some semi-solid, a little quite liquid. No history of a previous tumor, pulsating or otherwise, could be obtained.[1] A little further on are the details of a case in which my diagnosis (not my practice, as the case was not my own) was in fault (see Case IX.).

## Progress of Aneurism.

The tendency of aneurism is towards rupture; but this tendency is modified and controlled by so many circumstances that such an event may be rapid, greatly retarded, or altogether obviated; indeed, the tumor may be spontaneously cured, or may, if unfavorably situated, destroy life by methods other than hemorrhage.

Fusiform aneurisms, if at a distance from the heart, and neither cerebral nor pulmonary, do not often burst spontaneously, or, at least, such an event is long postponed. Sacculated and racemose aneurisms, if uncured, generally terminate by rupture.[2] Those which grow most quickly are most imminently exposed to such a result. The systemic causes of rapid increase are a powerful heart and a strong circulation; hence, youth and vigor, or a hypertrophied ventricle, as also restlessness and recalcitrance to the salutary ordinance of quietude, are potent auxiliaries of rapid growth. I have also observed that when the patients are decidedly rheumatic, and still more if they have recently suffered from acute rheumatism, the aneurism grows quickly, even though there be no cardiac hypertrophy.

Local anatomical conditions which conduce to rapid increase, are proximity to the heart; the situation of the tumor in a cavity, or surroundings of loose, unresisting tissue; a large size of the sac's mouth relatively to that of its body; an absence of active clot, whether owing to the shape of the tumor or to the quality of the blood; and inflammation, suppurative or otherwise, in the immediate neighborhood, whether produced by the pressure of the tumor or of independent causality. From all these considerations, it is evident that aneurisms are of very variable duration; nor must the various points above noticed be overlooked, when methods of treatment involving danger are under consideration.

Rupture of an Aneurism does not mean the slow yielding of dilated arterial coats, whereby the tumor, formerly inclosed in altered arterial tunics, comes to be no longer entirely thus surrounded, but is at some smaller or larger spot simply encapsuled by condensed adjacent structures, perhaps strengthened and padded by active clot (p. 390). Most of the large aneurisms which I have dissected, have thus been "consecutive." The word "rupture,"

[1] The limb was injected and split longitudinally. One-half is in the museum of the College of Surgeons, the other in Charing Cross Hospital.

[2] That is, unless pressure on some part destroy the function of a vital organ. The aneurism of which Mr. Liston, the celebrated surgeon, died, did burst; nevertheless, the hemorrhage was small, and pressure on the trachea was, together with rupture of the aneurism, the cause of death.

as used here, denotes that at some point the blood of the tumor is no longer circumscribed within a sac wall, however constituted; but that through a rent, greater or less in size, it has escaped, either outside of the body, into previously unaltered tissues, or into a cavity, passage, or duct.

The first form of rupture can only be by an open wound, sometimes traumatic, sometimes pathological, as when a phagedænic sore, or an abscess already discharging externally, opens also into an aneurism. In such an event, the more or less sudden appearance of a stream of bright arterial blood denotes with sufficient clearness what has occurred. Unless this be checked by nature or by art, faintness, deliquium, and death, soon follow. If checked, reaction of the system may yet bring on another hemorrhage, perhaps to be effectually commanded, perhaps proving fatal.

If the sac burst into a cavity or tube, the symptoms vary according to the situation and function of the part; their description must be relegated to a future occasion. But here we may notice certain differences as to the mode in which an aneurism bursts into serous or mucous-lined cavities. In the former case, the event is usually rapid; the rent is slit-like or stellate, with ragged edges; sometimes, if the sac have for some time pouched into the cavity, a considerable amount of thickening subtends or surrounds the opening. But rupture into a mucous cavity is a slower process, the round or nipple-like intrusion becoming first either ulcerated or gangrenous, when a little sinus-like track, or a small crack, permits the remittent escape of a few drops of blood at variable intervals. Afterwards, perhaps on some exertion, voluntary, emotional, or reflex, the slough or the floor of the ulcer gives way, and a sudden gush of blood into the cavity destroys life, either simply by loss of blood, or by interference with the functions of the inundated part. Occasionally, however, an aneurism thus ruptured may, nevertheless, continue to increase, and, the hemorrhage being small, may destroy life by pressure. If an aneurism burst into a joint, the synovial sac becomes exceedingly swollen, tense, and very painful; in some cases it pulsates. The diagnosis is then facilitated; otherwise it must chiefly be founded on the history, and on the many points of difference between this state and an acute synovitis.

Aneurisms, too, may open into large veins, or even into one of the chambers of the heart. This subject will be discussed under the head of arteriovenous aneurism.

An external aneurism may become ruptured without any outer wound diffusing its blood among the tissues of the limb. The rupture may either take place by a large rent and a sudden subfascial hemorrhage, or very much more slowly. In the former case, the symptoms are strongly marked and alarming: the patient generally feels something give way, or snap; then has a sickening sense of faintness; has to sit or lie down; becomes pale, and covered with clammy perspiration; and complains either immediately, or very soon, of violent pain in the limb, which rapidly swells. The tumor, whose existence was probably known, loses its definition, perhaps its outline altogether; that is to say, although the general tumefaction chiefly gathers about the site of the aneurism, no distinct and separable tumor can be felt there. Pulsation altogether ceases, not merely at its old place, but throughout the limb, except at its top; thus, for instance, the lower end of the axillary, or the common femoral, may be felt to beat, but below no arterial pulse can be found. The whole part feels numb and helpless to the patient, pain being to him the only sign of its life. Very soon it becomes hard, cold and brawny; then blotches of ecchymosis form on some parts, while in others mesh-works of veins appear. Subsequently, the whole becomes of a lurid red or dusky purple, and then, if the patient still live, gangrene announces its advent by the appearance of bullæ filled with serum stained of a deep purple or dusky crimson hue. These

symptoms may succeed each other by degrees, or may all be crowded into an hour or two, according to the extent of the rupture.

*Rupture into an Abscess.*—Inflammation and suppuration of the parts surrounding an aneurism are by no means uncommon; they may be traumatic, may originate in over-exertion, or may arise spontaneously—simply from the pressure of the tumor. Inflammation from the last-mentioned cause rarely occurs in an aneurism situated amid lax areolar tissue, but if the tumor press upon more irritable and more resistant parts, such as muscles, nerves, synovial membranes, and more especially the skin, even a moderate-sized aneurism may set up surrounding inflammation;[1] therefore an abscess superficial to the sac is not very uncommon, and is the complication which probably has most frequently led to infelicitous incision. The inflammation is not always confined to adjacent parts; it probably may sometimes originate in the sac, but more often attacks it simultaneously with, or soon after, its commencement in other structures, causing it to soften, together with the clot, which more or less slowly breaks down into a spongy, barely consistent pulp. Hence if such an abscess be opened or break, the discharge may at first be pure pus; but after a few hours or a few days, staining of a brownish purple, and the discharge of dark flocculi, will follow, and then a gush of bright arterial blood. Sometimes, if the aneurism have contained but little clot, the flow of blood occurs without warning.

Sometimes the abscess breaks into the aneurism, or the aneurism into the abscess, before the occurrence of any opening through the skin;[2] the pyogenic membrane may then not be firm enough to resist the pressure, which will still further inflame the already affected skin, and external rupture, if the case be left to itself, will, under such circumstances, be only a question of a few hours.

*Suppuration of the Sac* is a name commonly used to indicate that the aneurism itself is primarily and principally affected; probably it is not quite accurate, or rather does not express the whole truth, as surrounding parts are in all probability involved. Every aneurism in which blood has undergone passive clotting, is in some danger of suppuration (see p. 408), but there is no doubt that Broca and his immediate followers somewhat exaggerated its frequency.[3] When this accident occurs, the tumor, which already has hardened and has ceased to pulsate (from the formation of clot), becomes very tense, as also very painful and tender, with a sensation as of a tendency of something within the limb to burst. It is curious that, although the patient may have had no sense of pulsation while it was present, he will now feel a painful throbbing in the non-pulsatile tumor. These local symptoms are accompanied by considerable pyrexia, rigors, foul tongue, etc. After a few days the tumor, which has been abnormally hard, becomes diffused and softer. The termination depends upon whether the artery is and will remain sealed: if this be the case, an abscess containing broken down clots as well as pus results; if the vessel be or become patent, the mixture of abscess and ruptured aneurism occurs, as just described.

A small rupture of a non-suppurating aneurism gives rise to no violent or very urgent symptoms; faintness, etc., very slight and transient, succeeds, and accompanies some pain, and a more or less localized swelling of the limb; but the tumor itself loses its definite outline, and ceases to pulsate; and generally, and more particularly if the patient walk about and take exercise, some of

[1] The absorption of bone has been already alluded to; the pain so often accompanying this process points to its inflammatory nature.

[2] The symptoms of such a condition are given at p. 396.

[3] Many forms of treatment, now frequently used, cure by producing passive clot, and that without the frequent occurrence of suppuration.

the more severe symptoms of the larger form of rupture will after a time supervene. If now rest be enforced, and if the aneurism be situated among firm tissues, coagulation of the effused blood may occur, and thus a fresh consecutive sac may be formed; after a time pulsation returns, the tumor again becomes defined, and the patient regains his former state, the aneurism, however, being larger.[1] More rarely still, after clotting of the extravasated blood, that which is contained in the sac may likewise become consolidated.

Another mode of rupture, which takes place, unsuspected, much more commonly I believe than is usually supposed, is a slow leakage from between the laminæ of the clot which generally forms, in part, the sac of every aneurism which has attained a certain size, and which is not fusiform. No constitutional signs mark the moment of such an occurrence, even if it can be said to have a definite commencement: the oozing is intermittent; during, and for a certain time after its occurrence, the pulsation either ceases or is greatly diminished. The after events depend in part upon the submission of the patient to rest and quietude, but chiefly upon the sort of tissue in which the aneurism lies. If this be firm, the blood becomes circumscribed; if it be lax, as at the root of the neck, in the axilla, or in the prevertebral region, large non-circumscribed extravasations may form, and that without signs of hemorrhage, since the slow and gradual loss tells upon the system in much the same way only as any wasting disease. I can hardly illustrate this condition better than by the following case:—

Case IX.—In December, 1877, a man was in Charing Cross Hospital with a tumor in the left supra-clavicular region. This tumor bore no resemblance to aneurism: it seemed to spring from under the upper margin of the scapula and the trapezius, and to extend forward towards the clavicle; it was soft, but not quite soft enough to be called doughy, of very unequal consistence, and nodulated on the surface; it had neither pulsation nor bruit. The transversalis colli and the supra-scapular arteries could be felt beating in their course over the surface of the tumor which pressed them forward. The pulse on the left side was a little weaker than on the right, but the difference was not more than could be accounted for by pressure of any swelling or tumor on the subclavian. At the time of my first examination, I heard only a very indefinite history of aneurism; but I learned that the man's arm had been œdematous, and that he was a sad drunkard. He had a pale, sodden, lymphatic appearance. I negatived the diagnosis of aneurism, believing the tumor to be of a glandular nature, and that it had probably first originated in irritation of lymphatic glands, produced by their giving passage to a quantity of œdematous fluid.

In March, 1878, Mr. Hulke, under whose care the man had been in the Middlesex Hospital, read a paper on the case, detailing how he had cured the patient of subclavian aneurism by rest and low diet. I confess that the diagnosis seemed to me now still clearer, for Mr. Hulke's skill in diagnosis permitted no doubt of what had been the man's disease when he had been under that surgeon's care; and if Mr. Hulke had cured in that man a left subclavian aneurism, how could a growing tumor, above and behind the clavicle, be such an aneurism? The late Mr. Maunder and Mr. Morrant Baker suggested the idea of ruptured aneurism, but Mr. Hulke himself negatived the suggestion.

Some time, I suppose nearly a year, afterwards, chance threw this man, then an inmate of a workhouse infirmary, in the way of Mr. Baker. At that time, the condition of the parts affected was in an exaggerated degree that which had been described by me while he was in the Charing Cross Hospital. "An enormous, semi-solid mass occupied the supra-clavicular, infra-clavicular, and axillary regions,[2] and in this no pulsation could be detected."

After another interval, the post-mortem record follows: "An immense diffused aneurism was found occupying the whole of the left side of the neck, from trachea to ver-

[1] The increase having been so rapid or sudden should lead to a strong suspicion of what has occurred.

[2] When I saw him, the supra-clavicular was the only region involved.

tebræ, passing down behind the clavicle, filling the axilla, and through the superior aperture of the thorax into the left pleural cavity, occupying its upper third, and compressing the lung. It evidently had sprung originally from the left subclavian artery; for a portion of the latter for about two inches of its length, beginning just beyond the thyroid axis, was completely obliterated as a tube, and actually formed part of the anterior wall of the aneurism. Beyond this, for about an inch and a half, the vessel was normal, and on the axillary artery was a second aneurism of a fusiform shape, the size of a walnut, and completely plugged by laminated coagula.

"The main aneurism possessed anteriorly a well-formed sac, which was altogether deficient posteriorly, being replaced by the natural tissues. It was filled partly by firm, decolorized, and partly by loose, dark clots, in large quantity."[1]

This case requires little comment: it will of itself show the enormous difficulties under certain circumstances—indeed I might say the impossibility—of arriving at a correct diagnosis. The effusion of blood was so slow that the tumor went on increasing for about seventeen months before it reached the size described by Mr. Baker. At an earlier stage, when I saw it, its mode of increase caused it to exactly simulate a deep-seated, nodulated, glandular tumor, even to the characteristic pressing forward of the smaller vessels, while it had lost all the characteristics of aneurism. It had neither pulsation, bruit, nor pressure-pains, either on bone, nerve, or trachea—in fact, no trace of aneurism save the history. Enigmas so insoluble as that furnished by the above case are fortunately rare.

## Spontaneous Cure of Aneurism.

Spontaneous cure of aneurism may be produced by causes conveniently divisible into three categories:—

(1) Deposit of clot (active or passive) in the sac.
(2) Rupture of the sac.
(3) Inflammation,[2] suppuration, or gangrene of the sac.

Spontaneous Cure by Coagulation.—Of these methods, the first, the most usual, and the most to be desired, is divisible into two, viz., consolidation by *laminated or active*, and that by *loose or passive* clot; both may, or may not, be accompanied by obliteration of a certain length of the artery above and below.

The immediate causes of clotting within the sac may be either general or local.

The former consist of circumstances which so lower and depress the systemic circulating power, that the blood in the aneurism flows with a languid motion which greatly favors its coagulation. Such causes may be found in certain depressing and debilitating maladies, or may be artificially induced, as, for instance, by a greatly restricted diet, certain medicines, venesection, etc.; and, indeed, under either of these conditions, consolidation of blood within the sac has several times taken place. Another and very opposite condition may conduce to cure, viz., some severe inflammatory disease affecting a totally different part of the body. Thus a case of subclavian aneurism be-

[1] For these details, see an excellent paper "On Aneurisms which do not pulsate," by Mr. Morrant Baker. (St. Bartholomew's Hospital Reports, vol. xv. p. 75.) With characteristic courtesy, seeing that my diagnosis was erroneous, that gentleman has suppressed my name. I have no objection, however, in the almost impossible circumstances of the case, to acknowledge that, and to show how and why, I was wrong.

[2] The older writers considered all obliteration of the aneurism and the implicated artery as an effect of inflammation. This erroneous view led to many misinterpretations of occasional phenomena.

came solid during a severe attack of enteritis, and one of femoral aneurism during acute rheumatism.[1]

The local conditions are manifold, and must, to a certain extent, be matters of speculation, since when an old aneurism is found after death filled with firm clot, it will very generally be impossible to prove the circumstances which led to its solidification; yet, I think, we may take the following account to be correct.

It was pointed out a few pages above that most sacculated aneurisms contained, besides fluid blood, a certain amount of firm, laminated clot. This deposit rarely lines the sac throughout, but is situated in those parts of the cavity in which, from its shape, the blood stream is slight and slow, in which indeed, there may be a sort of backwater or counter-eddy, very tranquil, almost moveless. Fusiform aneurisms are, by their very form, precluded from possessing such quiet nooks or recesses, and hence they are less often and less richly provided with that lining of clot. Moreover, even sacculated aneurisms springing from a great length and from a wide periphery of the vessel—that is to say, having a large mouth in proportion to the size of the sac's body—are of less favorable form for the accretion of active clot than are those which stand out from a small section of the artery, and which have a small aperture of communication with the lumen of the vessel. A rough, uneven inner surface, or one divided into ridges and pouches, acts very favorably in promoting this process, and therefore, when once a certain amount of such a coagulum has been formed, it has great tendency to increase by deposition upon it of fresh layers of fibrine from the passing blood.

From this it will be plain that some aneurisms are so formed that one or other of the systemic conditions above mentioned, or some occurrence about the sac or the vessel, suffices to add the slight movement necessary to produce entire obliteration of the cavity; such are said to have a great tendency to spontaneous cure. Others are so constituted as to be very recalcitrant.

The circumstances which may occur to produce such a local retardation of the blood stream as shall lead to a freer deposit of clot are: fortunate form of tumor and situation of the usual clot deposit, favoring further extension of coagulum; pressure of the aneurism on the artery above or below; and displacement of a flake of the clot, and its impaction in such a position as to narrow the mouth of the tumor or of the efferent artery, if the aneurism be fusiform.

Concerning the first of these, little more need be said than has been said already. Laminated fibrine in a sac has always a tendency to growth, which may be frustrated by energy of circulation, constant movement, or a thousand other circumstances; if now such a patient have some temporary malady enforcing quietude, if the circulation be for some days depressed, if during a heavy sleep he lie in some position which may retard the blood-stream in the vessel implicated, he may by any of these, as by other fortunate circumstances, superinduce upon the old coagulum a new deposit, in a situation so opportune that the current in the sac is greatly lessened, and that the solidification of its whole contents becomes a mere question of more or less time. This process may take place in any sacculated aneurism, even though it spring from the largest vessel of the body.[2] The development of a new aneurism high up on any

[1] Archives Gén. de Médecine, 1824, and Pathological Trans., vol. vii. p. 201. The influence of acute inflammations in producing a rapidly fibrinating tendency of the blood is well known; I have, however, said only "may conduce," because further examples are required to establish a relationship of cause and effect between the existence of one disease and the cure of the other.

[2] Mr. Erichsen says "This process can only take place in aneurisms affecting arteries of the second and third magnitude, and never in those of the aorta." It is, however, not very uncommon to find in the post-mortem room cured and unsuspected aortic aneurisms. Dr. Cockle

given artery has occasionally, by slackening the blood stream in the vessel beyond, cured an older aneurism lower down.

That an aneurism may cure itself by *compressing its own artery*, either above or below the mouth, is a speculation first advanced by Everard Home,[1] in 1793; he was followed by Hodgson and Crisp.[2] Broca and Holmes throw some doubt on the possibility, or, at least, the probability, of such an occurrence. It is quite true, as Broca points out, that the cases cited by Hodgson are by no means conclusive; but it is impossible to deny that aneurismal pressure may obliterate an artery, while we have before us such a case as is detailed by Sir Astley Cooper.[3] The aneurism, which in this case was aortic, curled backward, and compressed the left carotid with such power as to cause its obliteration. If an aneurism, though it spring from a larger vessel, have power by its pressure to obstruct a healthy artery, there seems no reason to suppose that it would not also cause consolidation in an aneurismal sac; for in the first instance, total, or very nearly total, occlusion would be required; in the second, a mere mitigation of the blood-stream will often, as frequent experience has shown, procure solidification of the blood. I watched for several weeks, with great care, an aorto-innominate aneurism, which, advancing outward, bent down behind the clavicle and compressed the subclavian about its third part. Under this pressure, the outer part of the large tumor was gradually becoming solidified in the most interesting manner. But the man insisted on taking a long journey and going from care before the completion of the process, which, under fostering and favoring circumstances, might have led to entire cure.

If a cure have been effected by any of these means, obliteration of the artery up and down to the next large branch will generally occur in such vessels as the popliteal or femoral, but it is always secondary to the consolidation in the sac. In certain other vessels, as in the thoracic or abdominal aorta, the innominate, and usually the subclavian, unless the aneurism have been very large, the vessel preserves its permeability; the consolidated aneurism simply rests upon it, and the surface of the active clot, which is washed by the circulating stream, becomes coated with a smooth, shining tunic, indistinguishable from the normal inner coat of a healthy vessel.

A third local condition which occasionally leads to the cure of aneurism, is by *detachment of a flake or shred from the usual incrusting clot*. Such a shred may be only partially loosened from a spot near the mouth of the tmour, so that it flaps over the orifice, and, swaying in the current, acts as a valve, only mitigating, not entirely obstructing, the stream; or it may, whether quite detached or no, be washed into the vessel beyond, block it up entirely, and act as a total check to the circulation. The former method may, if the passage of blood be very much obstructed, give rise to the same symptoms as the latter, but if the circulation be merely retarded, no disturbance further than some coldness and numbness of the parts beyond, together with hardening and diminished pulse of the aneurism, is perceptible.[4]

The sudden occlusion of an aneurismal vessel by a detached piece of clot, is followed, unless the vessel be of unimportant dimensions, by a sudden,

(Lancet, vol. i. 1869, pp. 422–489) has described several such. Broca and Hodgson have each depicted one such cure. The mistake is a very important one, as likely to influence erroneously the practice of those who confide in Mr. Erichsen's generally excellent work.

[1] Transactions of the Society for the Improvement of Medical and Chirurgical Knowledge, vol. i. p. 140.

[2] On the Structure, Diseases, and Injuries of the Bloodvessels, p. 178.

[3] Med-Chir. Trans., vol. i. p. 12.

[4] Some of these symptoms depend upon the size and situation of the vessel. Thus, a blood-clot impacted in the aorta would cause much disturbance in certain vessels of the brain, with paralysis, or even death.

sharp pain in the limb, and by a sense of giddiness, faintness, and sometimes sickness. The pain in the part beyond increases, and then passes into severe tingling and heat, culminating in numbness and entire uselessness, closely simulating paralysis; indeed, the muscular helplessness may sometimes be combined with paralysis. The tumor ceases to pulsate, and the artery beyond to beat, the limb becoming cold and bloodless in some cases, while in others it is blue and gorged with venous blood. Gangrene is often imminent, and, doubtless, would more often supervene, if such conditions were not, as a very general rule, judiciously treated by covering and sufficient warmth. Many of these symptoms are common both to impaction and to rupture; the point of difference is chiefly to be found in the absence of swelling, and in the more or less gradual subsidence of the painful and even alarming phenomena.

Rupture of an Aneurism occasionally, though rarely, leads to a spontaneous cure. I saw, six years ago, a case which I am sure was one of ruptured popliteal aneurism, the consolidated blood compressing the artery and causing its obliteration, though not suddenly or rapidly; indeed, I was for three weeks ready at any moment to amputate the gentleman's thigh, and he was prepared to submit; but he got well after the fashion about to be described.

When an external aneurism bursts, the blood is effused into the tissues, and unless the limb be removed, or the rupture be very small, the patient frequently succumbs with the symptoms described at p. 400. But occasionally, as at that place was noted, the blood becomes encapsuled, partly by its own coagulum, partly by inflammatory thickening of adjacent parts. If the effusion have from the first been limited to a small spot by fascia, if the thickening be considerable, and if a proper amount of support be given by bandage or otherwise, the vessel becomes to a certain degree compressed, and, especially in a case so old that pretty large collateral branches have already been formed, may be obliterated. The patient having passed through a very imminent danger, very rapidly becomes a sound man again. This at least is the process which I believed I could follow in the case above alluded to. But having no anatomical fact to prove it, I would rather quote a very similar one—save that the patient suffered relapse—viz., Case XVIII. in Hodgson's work:[1]—

Case X.—A gentleman, about thirty years of age, after a day's hunting, felt a pain in his thigh, which he considered as rheumatic. A month afterwards he perceived a small, fluctuating tumor in the course of the femoral artery, about four inches below Poupart's ligament. The tumor increased, and the leg and thigh became œdematous. He was bled copiously, and restricted to a low diet. Compresses were applied above the tumor, in the course of the femoral artery, as high as Poupart's ligament, and the limb was rolled equably and tightly from the foot to the groin. The application of the roller increased the pain, and he suffered much from fever. This plan was continued for some months, when, on a sudden, the whole limb became extremely cold and benumbed, the tumor and upper part of the thigh put on a livid appearance, and serious apprehensions were entertained for the safety of the limb, which was hourly expected to become gangrenous. On the morning after this alarm, the pulsation in the tumor had ceased, but the livid color and the defect of circulation continued. The pain had abated, the fever was less, and the warmth of the limb began to return, and the size of tumor to diminish. From this time the patient continued to recover, but it was long before the limb regained its natural sensation, or the œdema subsided. At the end of six months he suffered no inconvenience from the remains of the disease, except that the upper part of the thigh was four inches larger in circumference than the opposite limb in the same situation. In this state he remained twelve years, when the swelling began to enlarge, and was attacked with a dull pain after violent exercise.

[1] The author gives it as a cure by pressure of an aneurism on its own vessel, a manifest error.

From this time the tumor gradually increased. When I saw him (says Hodgson), twenty years after the commencement of the disease, it had grown to an immense size, but did not possess any of the characters of aneurism. It had a firm, fleshy feel, and was void of pulsation, while no fluctuation could be detected in it. It continued to increase for two years, when the apex sloughed, and a quantity of brown sordes was discharged, mixed with clot, which had very much the appearance of lamellated coagulum in a putrid condition; no hemorrhage took place. A large cavity was thus exposed, the surface of which assumed a sloughy aspect, and the patient died in consequence of the fever and irritation with which it was accompanied. Upon dissection, the sides of the tumor, consisting of a firm, fleshy substance, were found to be in a sloughy condition; but no large vessel communicated with the cavity. The femoral artery, before it penetrated the tendon of the triceps, was obliterated for the space of three inches.[1] The body of the sac was reflected upwards upon the obliterated portion of the artery, which must have been compressed between the sac and the femur.

This narrative, highly characteristic in its first symptoms, and in the persistency of limb enlargement, differs from the type of such events in one particular only. If, after rupture, the patient does not succumb, but remains well for six months, and, *à fortiori*, for a year or more, he may, as a rule, be considered fairly safe from the consecutive gangrene which attacked this man after so many years. In all cases of recovery after such symptoms, the patient is, for about the period above specified, that is, from six months to a year, in constant danger, not as much from hemorrhage as from inflammatory destruction of the infiltrated tissues. As long, therefore, as measurement of the one limb against the other shows a large difference, so long does this danger exist. The vessel upon which the aneurism is seated usually becomes sealed; if when the tissues slough or suppurate, hemorrhage occur, it will be from other collateral branches, some of which open into the cavity, and, often thin and dilated, yield to the sphacelation.

Cure by Inflammation of the Sac, etc.—If the mode of spontaneous cure, just described, be most dangerous, indeed merely a narrow escape from death, so also, must we avow, are those now about to be specified, namely, inflammatory changes of the sac and its contents. It is to be observed that inflammation may be superinduced upon any of the processes, natural or artificial, which produce passive clotting of the blood; indeed, such a form of clot is apt to act as a foreign body and set up inflammation. And it is a little remarkable that inflammation of the sac and its surroundings tends to the formation of passive clot. It is difficult to account for this circumstance; we must be content with recording the fact.

Inflammation of the sac and neighboring parts is stated by Crisp and Hodgson to be capable of curing aneurism simply by producing clotting of the blood, and I believe that this may sometimes occur. The inflammation may arise from traumatism, as from a blow, strain, or over-exertion, etc., or may be produced simply by the pressure of the tumor. As long as the sac lies amid loose and insensitive areolar tissue, such irritation cannot take place, but when it comes to press on more sensitive parts, more especially on the skin, inflammatory conditions are by no means uncommon.

If resolution result, no effect will probably have been produced on the aneurism, or if any hardening and diminution of pulsation have occurred, such signs of amelioration may be merely temporary, the loose clot with which the sac has been in part filled being so soft that it easily breaks down and

[1] This is ambiguous. I presume Hodgson does not, by triceps, mean the adductor magnus; probably the canal, Hunter's, between the vastus internus and the long adductor, is intended; if so, the superficial femoral would have been obliterated up to its junction with the deep (profunda) branch.

is carried away in the blood current. The disease reverts to its former condition, except that the sac wall is probably softer, more distensile, and more fragile than before. But in some rare and most fortunate cases, the tumor, which at the first advent of inflammation became more tense and had a more violent pulsation, ceases either slowly or suddenly to beat, becomes harder, and, when the inflammation has subsided, may begin slowly to diminish.

*Suppuration*, another result of the inflammation, may at first involve simply surrounding tissue, or the aneurism alone; more commonly it attacks simultaneously both parts. Wherever the commencement may be, it is a highly dangerous condition, which, however, though it usually results in loss of limb or life, may lead to cure.

An inflammatory abscess adjacent to an aneurism runs the usual course: enlarges, points, is opened, or bursts; pure unstained pus comes away, if the inflammation have been severe and extensive enough to close with clot not only the aneurism, but also the implicated vessel; and, if time enough have elapsed to permit the formation and adhesion of coagulum, no further accident may arise. Unfortunately, the course of events is more often thus: the artery may never have been filled with clotted blood, or, if so, only with friable clots which soon soften and break down, so that a few hours or days after the discharge of pus, a gush of bright blood, which may be either sudden or preceded for some hours by sanguinolent pus, places the patient in such imminent danger that amputation is urgently demanded. Or the abscess may open into the aneurism before pointing on the skin; or, again, suppuration may occur within the sac and in its neighborhood simultaneously. The symptoms of the former condition, prior to bursting or opening, are obscure, but when either of those events occurs, the admixture with the pus of loose, tawny-purple coagula, and generally of fibrine in lamellæ, sufficiently indicates the nature of the case. Suppuration within the sac, which must always be looked for when there is reason to believe that as a result of inflammation it has become filled with passive clot, is marked by extreme tension and hardness, some increase of size, and a sense of throbbing in the non-pulsating tumor, the pain being considerable and imparting a peculiar sense of bursting. The occurrence of hemorrhage when an opening, artificial or otherwise, is made, depends upon the presence and density of clot in the vessel, rather than in the aneurism; it must always be remembered that, although no bleeding may occur at the time of opening, the vessel may, by breaking down of the soft clot, become permeable, so that a sudden gush may destroy the patient, or that slighter and recurrent hemorrhages may cause the loss of either limb or life.

A few cases have occurred[1] in which, after discharge of pus and clots, and after one or more attacks of hemorrhage, the abscess has contracted, the bleedings have ceased, and the patient has been cured of the aneurism; the process whereby this takes place is obscure, and the event is too rare to affect prognosis.

*Gangrene of the sac* is also extremely dangerous, but not as often from immediate hemorrhage as from exhaustion and its results, because the gangrenous condition is usually accompanied by inflammation sufficient to close the vessel. It is not common in deep aneurisms surrounded by cellular tissue; but attacks rather those that grow so rapidly as to press upon more sensitive parts without affording them time to accommodate themselves to the disturbance, and it is especially liable to occur when the skin becomes rapidly stretched. This structure, when gangrene threatens, becomes shiny on the surface, of a dusky

[1] See Broca, Des anévrysmes, etc., p. 167; Hodgson, p. 103; and Crisp, p. 107.

red hue, and almost insensitive; then a patch puts on a bluish, bruised look, and becomes afterwards of a brownish black. If the vessel have remained patent, a little sanguinolent oozing from cracks in this dark spot forebodes an imminent hemorrhage which will not be long delayed. If the implicated artery have been sealed, lump after lump of detritus, consisting of sloughed tissue, partially decomposed active and passive clots, together with a quantity of foul pus, comes away; the patient escapes hemorrhage, but is in great peril of exhaustion and blood poisoning.

These modes of spontaneous cure have been dwelt upon at considerable length, because they are most important: many of them as indicating methods to be pursued, others as illustrating dangers to be avoided.

In order to afford a compendious view of these processes I will place them in tabular order:—

| Mode of Cure. | Produced by |
|---|---|
| 1. Deposit of clot, active or passive. | Lessening the quantity of blood in the body.<br>Lowering the heart's action.<br>Form of tumor.<br>Diminution of blood stream through the artery.<br>Pressure of aneurism on artery.<br>Displacement and impaction of a clot. |
| 2. Rupture of sac. | Traumatic.<br>Over-rapid growth. |
| 3. Inflammation, suppuration, and gangrene. | Traumatic.<br>Presence of passive clot.<br>Rapid growth and pressure on irritable tissues. |

## Treatment of Aneurism in General.

All methods of treating aneurism are founded upon the processes of spontaneous cure, every one of which has been imitated by art. It need, however, hardly be pointed out that that natural process which is the safest, is the one most worthy to be copied; hence, several modes of treatment which aimed at cure by such dangerous routes as rupture or suppuration of the sac, have fallen into complete, or almost complete, disuse;[1] nor would it answer any good purpose to discuss here obsolete methods which are now mere matters of history.

At the present day, the treatment may best be divided into the medical or systemic, and the surgical or local.

## I. Medical Treatment of Aneurism.

The medical treatment of aneurism is founded on the method of Valsalva, which aims at reducing the quantity of blood, and lowering the action of the heart,[2] by "keeping the patient in bed about forty days, during which time one or more venesections should be practised, enemata be used, wine be forbidden, and only such an amount of food and drink be given as is enough to support life; and indeed not merely in two portions in the whole day, but the

[1] Mr. Syme revived some years ago the method of Antyllus, founded on rupture.

[2] Valsalva left behind no writings on this subject; but his friend, Hippolytus Franciscus Albertinus, in his work entitled Animadversiones super quibusdam difficilis respirationis vitiis, a lœsâ cordis et præcordiorum structurâ pendentibus (1748), has given a complete account of the plan which both together had devised.

daily portion should be administered on [divided between] three or four separate occasions, so that the small quantity given at each may never fill the bloodvessels." The same, or much the same, regimen, with the exception of bloodletting, is even now practised, and has of late been more particularly recommended by Mr. Jolliffe Tufnell.[1] The regimen as at present adopted may be described as entire rest, with either a low diet or a dry diet. The rest is to be in bed, and the patient must be enjoined to refrain from frequent movement of the limbs—if the aneurism be thoracic the arms are to be employed as little as possible—contrivances for holding a book or other articles being provided. The change from total[2] to semi-recumbency is all that should be permitted, and even in this the patient should be helped. He should not get out of bed for any purpose whatever.

The low diet may be arranged somewhat on this pattern—Bread, 10 ounces; butter, 1 oz.; rice or tapioca pudding, 6 ounces; milk, 1 pint; this amount, divided into three or four meals, should suffice, as a general rule; but some patients, especially among the less educated classes, to whom physical privation is unbearable, become recalcitrant under such restrictions, and it may be advisable to allow once or twice a week a little fish or some boiled meat. The dry diet may be formulated thus—for breakfast and supper, bread, 4 ounces; butter, $\frac{1}{2}$ oz.; milk, 2 ounces. For dinner, meat, 3 ounces; bread, 3 ounces, water or milk, 3 ounces. If the quantity of fluid can be still further reduced, some advantage may be gained, and thirst can be obviated by occasionally sucking a small piece of ice, or by gargling the throat with iced, acidulated water. If after either of these plans has been carried out for six weeks, the aneurism have become consolidated, or if, on the contrary, no benefit have resulted, the return to a fuller and more natural regimen must be very cautiously made; the increase must be slow and measured, and its effect must be carefully watched.

I cannot but think that the reaction against the too copious and frequent bleedings of our forefathers is somewhat excessive. Indeed, at the present day, if a patient should be bled to the amount of a pint, his friends would, probably, ascribe all the subsequent evils, inseparable from his disease—perhaps even his ultimate death—to the venesection. Nevertheless I have no hesitation in saying, that, in certain cases, a suitable and perhaps a reiterated bleeding would, at the commencement of treatment, save much time, and enhance the efficacy of the diet system. This would more especially be the case, when, from pressure upon large veins, much congestion existed—the air-tubes being narrowed and the lungs hardly able to aërate the quantity of blood sent to them. In all such cases, to diminish the mass of blood in the system gives rapid relief; but this must be done cautiously, since syncope must not be risked. The mere influence of bleeding on the action of the heart is, however, not the only point to be considered; its effect on the blood itself is well ascertained, and even more important—namely rapid coagulation. This has been well shown by Thackrah, Gulliver, and others, and is one of nature's most potent means of arresting hemorrhage. In such cases the facility with which the blood coagulates is in very close proportion to the amount which has been effused.

Medicines, therefore, which act by simply reducing the force and rapidity of the heart's action, cannot tend as directly to the cure of aneurism as a bleeding which has an equal cardiac influence; but they may in other ways be less injurious, and their effects may certainly be recovered from with less diffi-

[1] The Successful Treatment of Internal Aneurism, etc. London, 1864; 2d edit., 1875.

[2] Some patients with aortic aneurism cannot lie down; they must be supported day and night in a half-lying posture.

culty. Thus, such drugs as *belladonna*, or its alkaloid,[1] and *hydrocyanic acid*, may be used, and with a certain advantage. The former drug has the effect, in thoracic aneurisms, not merely of lessening the rapidity of the heart's action, but also of alleviating pain; and, more especially if there be dyspnœa, of diminishing the laborious efforts of obstructed respiration. I have found less benefit from *digitalis*. Great caution in the use of this drug is necessary, since its action appears cumulative; and after long administration, with apparently little effect, it occasionally retards the cardiac pulsation suddenly, and sometimes to an alarming extent. *Tincture of aconite*, in from two to five minim doses, every three or four hours, will generally rapidly reduce the pulse to sixty in the minute, and to a more feeble beat. The action must be carefully regulated. A case of Dr. Pancoast's (subclavian aneurism) got well while the patient was suffering from a poisonous dose of aconite given by mistake. *Veratrum*, if used at all, may be most safely employed as veratria ointment over the chest, if the skin be unbroken.[2] The action should, however, be very carefully watched. In one case in which I thus used it, relief, and I think a certain amount of retardation in the growth of the tumor, ensued.

*Bromide of potassium* is of decided advantage when pain or irritation arises from direct pressure on nerves. I have seen the irritating and distressing cough which is caused by disturbance of the recurrent laryngeal nerve, in certain cases of thoracic aneurism, much mitigated, and in one or two instances almost subdued, by twenty-grain doses of this drug; I have seen, also, severe pain from pressure on the popliteal nerve almost disappear.

*Iodide of potassium* has by some writers been greatly extolled. It was first employed in aneurism by Dr. Chuckerbutty, of Calcutta, who noted the consolidation of an aneurism while the patient was for some other disease taking large doses of that drug. Since then it has been by some surgeons largely employed. My own experience, like that—as he tells me—of Sir William Gull, and that of Mr. Holmes,[3] is not favorable, although under certain conditions, to be named immediately, the drug may alleviate. There is, since direct experiment on the human subject is inadmissible, very great difficulty in either proving or disproving the value of a drug in this sort of malady. We cannot isolate it; we cannot give the drug and do nothing else. Thus, in turning to published records we find always that patients who come under treatment are placed at entire rest, debarred from stimulants, and given low diet; when, if the iodide be administered, the advantage gained is put down, in whole, or in great part, to the use of the drug. Nor have I been able to find a single case in which the medicine, given without these more potent elements of success, has proved curative of the aneurism. On the other hand, there are a great many[4] records of patients who, after improving under the whole system of rest, diet, and drug, have got tired of restraint and resumed their ordinary mode of life, and then, though still taking large doses of the iodide of potassium, have quickly relapsed, and generally rapidly died.

The theory of the syphilitic nature of atheroma and aneurism is one reason

[1] The most reliable, and, indeed, the only stable compound of atropia is the salicylate. The formula is this:—

| | | |
|---|---|---|
| Take of | Atropia, . . . . | 5 grs. |
| | Salicylic acid, . . . | $7\frac{1}{2}$ grs. |
| | Hot water, . . . . | 10 fluidounces. |

Rub the atropia down first into a very fine powder, then little by little mix the salicylic acid with it; add slowly the hot water. The whole must dissolve, and the solution must measure or be filled up to 10 fluidounces. The dose is 10 minims—that is, $\frac{1}{100}$ grain of atropia.

[2] The United States Pharmacopeia preparation is 1 in 25; the English, 1 in 60.

[3] System of Surgery, second edition, vol. iii. p. 437.

[4] These are so scattered and so multitudinous that it would be useless to refer to them.

for the belief in the value of iodine; another is the fact that, under certain circumstances, this drug undoubtedly relieves a species of pain which accompanies the growth of certain aneurisms. That wearing and peculiarly distressing pain which is produced by pressure of the tumor on bones and periosteum, is undoubtedly mitigated—may even for a time be entirely subdued—by taking from forty to ninety grains, in the twenty-four hours, of iodide of potassium. Hence a relief of symptoms which by no means implies improvement of condition.

The value of iodine given internally is most marked in periostitis, chronic thickenings, and slow inflammatory enlargements, whether strumous, syphilitic, or rheumatic; in fact, in such conditions as culminate in fibrous or fibrillating deposits. But all cures of aneurism, save those by suppuration and sloughing, are based upon coagulation—upon the fibrillating qualities of the blood—which is antagonized by iodine. I cannot but think that the very rapid relapse and quick progress of the disease which overtakes many aneurismal patients, who at first seemed to derive benefit from the rest and the iodine, is often due to a non-coagulating condition of the blood, produced by large doses of this drug.

## II. Surgical Treatment of Aneurism.

Medical treatment is, in certain cases, the only available resource, as in a large proportion of thoracic, and in a few other aneurisms; but for some internal, and for nearly all external aneurisms, treatment applied directly to the implicated vessel—*surgical treatment*, as it is called—can be employed.

The surgical methods employed in cases of aneurism, may be divided into such as aim at cure: (1) By destruction of the sac—they are imitations of the cure by gangrene or suppuration; (2) By applying coagulants directly to the blood, following the method of cure by passive clotting; (3) By mitigating or suppressing the circulation in the vessel and tumor, in order to induce coagulation generally, and preferably by active clot.

As each of these is modelled upon some natural process, so each is liable to the same sources of failure as the spontaneous method of cure which it imitates. The *first* may cause death by exhaustion and blood-poisoning; the *second* exposes to the risk of recurrence, or inflammation with its sequelæ; but the *third*, if successfully completed, affords an entire and permanent cure. The methods employed are as follows: (1) The use of cauteries and the method of Antyllus;[1] (2) Injections of coagulating fluids, the introduction of solid bodies into the sac, the application of heat, galvano-puncture; (3) Manipulation, flexion, various forms of compression, different modes of arterial deligation.

Concerning many of these methods, only sufficient need be said to indicate that they have been used—in order to obviate the possibility of any surgeon, after consulting this work, adopting, under the impression that they are new, plans which have been tried and abandoned as useless or lethal. With this object in view, I shall mention briefly a number of methods, rather as points of science than as examples to be followed, save in exceptional circumstances.

Cauteries.—Of the use of cauteries nothing need be said further than that the method has been employed by Chassaignac and Neumann for small aneurisms, one of the palm, the other of the anterior palatine artery. The remedy, successful in both instances, can only be employed when the sac is minute.

[1] The "method of Antyllus" will be referred to in connection with the treatment by ligation.

It imitates the most unfortunate and dangerous form of spontaneous cure, and the practice is certainly not deserving of imitation.

*Coagulants applied directly to the blood* may be either chemical or mechanical.[1] I shall limit myself to a description of the injection of coagulating liquids, the introduction of certain solids, and galvano-puncture or electrolysis.

INJECTION OF COAGULATING FLUIDS.—Injection of fluids into aneurismal sacs originated with Monteggia,[2] at the beginning of this century, and shortly after was advised by Wardrop. Various fluids were recommended, but they all yielded after a little to the superior coagulating qualities of the perchloride of iron, with the use of which, and of the fine syringe employed for the purpose, the name of Pravaz is intimately united. Such injections may be valuable in some cases of nævus and aneurism by anastomosis, but their use in aneurisms proper is only admissible in certain cases. Since each portion of a drop of the solution immediately coagulates into a soft solid the blood with which it comes in contact, means must be taken to retain the little lumps thus produced, in the sac, as otherwise they will entirely or in part escape along the artery below, as emboli; hence the method is only practicable when the vessel can be compressed below and above, so that the chemical may act upon stagnant blood.[3]

The mode of procedure is as follows: First, the vessel above and below must be entirely commanded, and then the fine needle-canula of a properly-graduated hypodermic-injection syringe is passed with a quick but properly restrained action into the tumor, the appearance of a drop or two of arterial blood marking its entrance; it should next be moved from left to right gently, but sufficiently to ascertain that its end lies in a cavity; then the syringe, filled with the injection-fluid, is to be applied to the socket of the needle, and the requisite quantity very slowly injected, while the point of the instrument is made to change its place in the sac, so as to distribute the liquid into various parts. When the amount fixed upon has been injected, or previously, if sufficient coagulation appear to have taken place, the piston should be withdrawn a little, lest some of the fluid hanging to the end of the needle-canula should irritate the sac, and then the instrument may be removed.

According to Signor Marsacci, the latest writer on this subject, and M. Dieulafoy, a little earlier, the solution should be weak, 1 part of the salt to 15 or 20 of distilled water; and the amount should not exceed five drops to every ounce of blood that the sac may be estimated to contain. After the withdrawal of the needle, the puncture may be protected with collodion, and pressure on the vessel above should be continued for an hour, and on that below for double the time, if it can be borne.

Since coagulant injections can only be employed with some approach to safety from the risk of embolism, when a sufficient length of artery to afford space for pressure lies both above and below the sac, it follows that any aneurism to which this treatment can be applied is well situated for almost any curative means, and the duty of the surgeon is to choose the safest. The danger of embolism may, by great care, and, as I cannot help thinking, by good luck,

[1] Space hardly permits a historic account of the use of a number of coagulants, such as heat, as employed by Sir Everard Home; certain powders; and other means which may be termed eccentric.

[2] Institutions de Chirurgie, 1815.

[3] Certain surgeons have thus treated aortic, innominate, and subclavian aneurisms; evidently, from what has just been said, an improper application of the method, and destined to prove injurious.

be avoided; but the danger of suppuration, and even sloughing, of the sac, through the irritation of a loose clot soaked in the coagulant fluid, is ever present, and against such peril, when he has made the injection, the surgeon is all but helpless. There can, I conceive, be very few aneurisms which can safely be treated by coagulating injections, which cannot be less dangerously treated by other methods.

Introduction of Foreign Bodies.—The introduction of solids into the sac is a method which originated with the late Charles Hewitt Moore, of the Middlesex Hospital, in 1864.[1] He selected for this experiment a case of hopeless thoracic aneurism, introduced into the sac a fine canula, and through that tube passed into the cavity twenty-six yards of fine iron wire. The operation was easy, and almost painless; the hemorrhage slight; but the effect injurious. Inflammation of the sac and of the surrounding parts, certain embolic infarctions of the kidney, great pain, and death on the fifth day, is the summing up of the case.

In 1873, Dr. Levis, of Philadelphia, slightly modified this procedure by using, instead of fine wire, horse-hair.[2] The aneurism was of the right subclavian artery. The patient died in four days. At the autopsy, the horse-hair was found behind the upper lobe of the lung, the aneurism being ruptured. "On dividing the upper lobe of the right lung, there was found a mass of black, clotted blood, behind it and extending beyond the line of the ribs, especially in the axillary region immediately below the clavicle, nearly two inches. In the upper portion of this soft clot a dense white clot was found attached around the lower aneurismal opening in the subclavian. In the posterior part of the fibrinous clot were found the horse-hairs."

In November, 1873, Mr. Bryant treated in the same way a popliteal aneurism which had resisted pressure, passing into the tumor about twenty feet of horse-hair while the femoral was compressed. "The leg was bandaged with cotton-wool. The anterior tibial could be felt pulsating. Half an hour after the operation, the pulsation had diminished."[3] The patient survived four days, the procedure apparently not contributing to death as much as did a heart affection, and the previous very zealous compression for over one hundred hours. The sac was found partially filled with clot mixed up with horse-hair, but, as a month before death it had been noted that there was much clot in the sac, there is plainly difficulty in ascribing to the pressure and the horse-hair their respective shares in the local and general result.

The introduction of needles is a method which dates from the time of Sir Everard Home (1796), who added heat to the mere acupuncture. And the tendency of blood in slow motion to coagulate upon any solid against which a mitigated current may play, has induced many well-known surgeons—Velpeau, Pravaz, Agnew, and others—to try this method, but without much practical result. The most successful case is that of Dr. Macewen.[4] The aneurism was of the popliteal artery; pressure had been but partially successful; a fine needle was introduced and moved every ten minutes for one hour, during which time, and for fifteen minutes longer, pressure was continued. It is to be observed that the influence of the needle is in this case doubtful; many an aneurism, which had previously resisted, has been cured by the last half hour or so of pressure. Mr. Heath,[5] after amputating without benefit at the shoulder-joint, in a case of subclavian aneurism, used acupuncture, but

[1] Medico-Chirurgical Transactions, vol. xlvii. p. 136. I believe some attempts had, in earlier years, been made to cure aneurism by passing into the sac very fine iron-dust or iron-filings.

[2] Philadelphia Medical Times, March 28, 1874.

[3] Pathological Transaction, 1877, p. 103.

[4] Lancet, vol. ii., 1876, p. 184.

[5] Medico-Chirurgical Transactions, vol. lxiii. p. 71.

without good result; he introduced six needles, each pair crossing in the sac, and left them for four days. In his paper he says that Mr. Marshall has on more than one occasion thus produced temporary clotting to a considerable extent. Constantin Paul[1] also employed needles, but kept them in only fifteen minutes on one day, and, after three days interval, one and a half hours; and then, after three weeks, repeated the same two punctures. The benefit was, he affirms, very considerable. Bacelli[2] advocates the introduction of very fine watch-springs which he believes would provoke coagulation, and then become oxidized and pulverized, and strengthen the clot, but his two cases terminated fatally without any apparent benefit.

Thus a great number of substances have been introduced, some of which are not even here named. No surgeon would choose such treatment if any more efficacious and more direct means were applicable, but in certain cases, when nothing else could be effected, some foreign substance might be employed; I should, however, strongly deprecate the use of iron wire, horse-hair, or such coarse solids, pushed irrecoverably into the body of the aneurism; none of the patients on whom this was done lived long afterward; of course, some clot was found about the coils, but inflammation, suppuration, or even bursting of the sac are all complications to be considered.

GALVANO-PUNCTURE.—Electrolysis or galvano-puncture, as the method may indifferently be called, was introduced into England by Benjamin Phillips, in 1829, as an improvement on Everard Home's idea of coagulating the blood of an aneurism by means of heated needles. But his proposition met with no consideration. Shortly afterwards, in France, M. Alphonse Guérard suggested to M. Pravaz the same idea,[3] and that physician, accepting it with enthusiasm, established the method, which has been carried out and perfected more especially by Ciniselli,[4] and in England by Duncan, Fraser, Poore, and Althaus. It is thus to be carried out. The battery must be of large tension and small intensity, that is, should have a goodly number of small elements; the machine of Stöhrer, or the Leclanché battery as arranged by M. Foveaux,[5] answers very well, or better still, since in it the amount of immersion can be regulated, the Foveaux-Smee arrangement.

There should be either several—from four to six—very thin needles arranged in a lash on a subdivided conducting cord, or one steel needle, on a single or on both poles; in either case, the needles must be well insulated down to a short distance from the point.

Thus far all are agreed; but beyond this the galvanists differ—one choosing to insert the negative, another the positive, a third both poles; if one only be inserted, the other ought to be applied to the skin, but not over the sac, by means of a wet sponge. From the negative pole, especially if used alone, a froth composed of gas bubbles suspended in a very soft, loose clot is formed. From the positive, a firmer, blackish, but small clot is produced, and there is also formed[6] a black fluid, which appears to be produced in considerable quantity, in appearance and consistence like thin tar. If a patient is to be subjected to this treatment (and I need hardly say that only internal aneurisms—scarcely any other than intrathoracic—are suited for its adoption), he must be in bed and semi-recumbent, and should not have chloroform or ether,

[1] Gazette des Hôpitaux, No. 54, 1879.
[2] Bulletin de l'Académie de Médecine, 1878.
[3] Lettre de M. Pravaz sur l'Acupuncture de M. Velpeau. Gazette Médicale de Paris, Janvier 8, 1831.
[4] Sulla elettro-puntura nella cura degli Aneurismi, 1856, and a later, 2d edition.
[5] Of the well-known firm of Weiss.
[6] Dr. John Duncan. British Medical Journal, May 20, 1876.

but may, as Dr. Poore[1] has pointed out, be somewhat narcotized by the hypodermic use of morphia. The needles, and I myself prefer to employ both, should be oiled and inserted with a quick but not strong thrust, and when non-contact of the two within the tumor has been verified, the battery is to be connected. The effect on the pulse and vital powers must be watched, and, unless untoward appearances arise, the use of galvanism may be continued for one or even for two hours, provided that no redness appear around the punctures. If both poles have been inserted, the unguarded end of the positive needle will have been almost entirely dissolved away in the time above given, if the action have been sufficiently strong. Removal of the needles must be effected with great gentleness, so as to disturb as little as possible any clot that may have formed upon them, and so as to avoid also any rending which might be produced by the needle-point, which will possibly have been roughened by the solvent action of the galvanic current.

The immediate result is nearly always a certain increase in the hardness of the tumor, and a certain diminution of the pulsation; or at least this feels more distant. The next thing is nearly always that these apparently favorable signs disappear. The clot, if any, which is formed by the galvanic current, is usually as evanescent as the will o' the wisp.

Ciniselli gives the following table:[2]—

| Aneurism of | No. of Cases. | Cures. | Deaths. |
|---|---|---|---|
| Aorta, | 37 | 6 | 3 |
| Innominate, Carotid, and Subclavian, | 13 | 3 | 6 |
| External Iliac, | 2 | 1 | 0 |
| Femoral, Popliteal, and Brachial, | 26 | 16 | 3 |
| Smaller Vessels, | 8 | 6 | 0 |
| Total, | 86 | 32 | 12 |

a table which I confess to regarding with considerable doubt, not as to the veracity and good faith of the author, but as to the interpretation of the results. I do so because of five patients whose cases are recorded in a later communication,[3] three did not even seem to have been benefited, one did so seem for a few days, one went from care, apparently much benefited, but returned within a month, and died almost immediately from asphyxia. Still more recently,[4] Dujardin-Beaumetz, in relating to the Société Chirurgicale a case of aortic aneurism which he had treated unsuccessfully by galvano-puncture, quoted a letter received from Ciniselli, whence the following statistics are extracted. Of 29 cases, in 11 the relative improvement had lasted 4 years, 37, 33, 21, 17, 16, 7, 7, 6, 4, 1, months. In 7 others it had lasted 28, 16, 12, 8, 6, 3, 3, months, and still continued. In 11, there had been no improvement.

Experience in other countries has been less favorable, as shown, for instance, by the table given by Dr. Poore:[5]—

| Aneurism of | No. of Cases. | Cures. | Deaths. |
|---|---|---|---|
| Thoracic Aorta, | 8 | 0 | 8 |
| Innominate, | 1 | 0 | 1 |
| Subclavian, 3d Part, | 1 | benefit. | 0 |
| Ulnar, | 1 | 0 | 0 |
| Femoral,[6] | 1 | 1 | 0 |

[1] Electricity in Medicine and Surgery, p. 253.

[2] Sulla elettro-puntura nella cura degli Aneurismi.

[3] Sopra alcune Aneurismi della Aorta toracica osservate dopo il 1870.

[4] Union Médicale, No. 136, 1877.

[5] Op. cit., p. 253.

[6] This case having been treated by pressure combined with electro-puncture, renders it doubtful to which the cure is due.

Taking what later (after 1877) records are available, I find 8 cases. Of the several patients.

4 died during treatment,[1]
1 was not improved, and died in 13 months,[2]
2 were benefited, but not cured,[3]
1 was cured[4] or greatly benefited.

The aneurisms best adapted to this treatment are, undoubtedly, those about the upper part of the aorta, which are not very large, but which have already perforated, or at least pushed forward, the chest wall. Mere fusiform dilatations are probably quite beyond hope of benefit, since the blood must in them sweep past the needles too rapidly to be affected by the galvanic current. A sacculated aneurism with a protruding diverticulum, or, still better, one that is set like a bud on the vessel, and has not too large a mouth, so that the circulation may be somewhat slow, is certainly the most hopeful form for this treatment, because in such a sac the retarded current affords to the galvanism some chance of producing a clot which may afterwards extend, and which is less likely to be washed away.

The dangers of galvano-puncture are bleeding from the needle punctures (hardly to be regarded, unless very large needles have been used); formation of an eschar, or of an abscess, between the skin and sac; inflammation of the sac; embolism;[5] and sudden depression of the vital powers—but in truth none of these save embolism are very imminent or potent.

We cannot quit this subject without staying to consider the two parts of which the treatment consists, namely, the galvanic current and the foreign body, as likewise the possibility that the presence of the needle has as much, perhaps more, to do with the benefit when it accrues, than has the galvanism. If Messrs. Heath, Marshall, Macewen, and Paul, are correct in their statements, we have evidence of about an equal rate of benefit on the introduction of needles, whether or no they be connected to a battery.[6] M. Paul, in his paper above quoted, asserts that the benefit in either form of treatment is not due to coagulation, but to an inflammation of the aneurismal wall which thus becomes thickened.

Parenchymatous Injection of Ergotine.—In connection with the treatment by injections, another method may be mentioned, which does not, however, aim to effect a cure by directly producing coagulation, but is rather a topical application of strictly medical measures. The *parenchymatous injection of ergotine* was introduced, in 1869, by Langenbeck, who exhibited two cases so treated at the Berlin Medical Society. He prefaced his remarks with these words:—

"It is well known that in obstetric medicine the secale cornutum is a very valuable remedy; it acts by stimulating and calling forth uterine contractions,

[1] Two, Thoracic Aorta. Drummond. Lancet, Aug. 9, 1879.
One, " " Gardner. British Medical Journal, July 19, 1879.
One, Abdominal Aorta. Moudan. Lyon Médicale, No. 4, 1879.

[2] Omboni. The case is described as improved, but it is not easy to see in what the improvement consisted. Il Raccoglitore Medico, Febbr. 1877. (Thoracic Aorta.)

[3] Carter. Lancet, Nov. 30, 1878. Boucquoy. Progrès Médicale, No. 4, 1879.

[4] Verradini. Gazetta Med. Ital. Lomb. No. 3, 1878. A very rapid, apparent cure (24 minutes); ice and rest afterwards. Relapse in 10 weeks; same treatment again produced seeming benefit, which was of longer duration.

[5] Dr. Clifford Allbutt found in a case of subclavian aneurism the opposite carotid obstructed. Brit. Med. Journ., May 20, 1876.

[6] Since this was written, a case has been reported in the Lancet, Oct. 22, 1881, of an aneurism, either aortic or aorto-innominate, greatly benefited or perhaps cured by electro-puncture. The surgeon who reports the case, himself observes that, after using the Stöhrers battery for an hour, he tested the current on his forehead, and found it almost nil, and that therefore the result may have been attributable to the mere presence of the needles.

and thus is also a hæmostatic in post-partum hemorrhage. Hence we may conclude that ergot acts on organic muscular fibres, causing their contraction; it was these considerations that induced me to employ the injection of ergot in a case of aneurism."[1] The material used was the aqueous extract of Bonjean, thus diluted:—

Extract of ergot, $2\frac{1}{2}$ parts.
Rectified spirit,
Glycerine, of each, 7 parts.

He began with 0.03 gramme,[2] and from the 6th of January to the 17th of February, about two grammes of ergotine were injected, in doses varying from 0.03 to 0.18 gramme, at intervals, as a rule, of three days. An ordinary hypodermic syringe was employed, and the fluid was placed under the skin covering the aneurism. In the first case, one of subclavian aneurism, there was much improvement, considerable diminution both in size and pulsation having occurred.[3] Pain, too, almost entirely disappeared, so that, even after the first injection, the patient, who had been very sleepless, and who thought that the medicine was a narcotic, expressed himself as greatly pleased at having passed a quiet night.

Langenbeck's second case was one of aneurism of the radial, as large as a hazel-nut, in which, after a single injection of ergot, the tumor disappeared!

In 1871, Dutoit, of Berne, published a successful case of combined pressure and ergotine injection, in subclavian aneurism, using fifteen injections in thirty-seven days, commencing with half a grain, and ending with three grains.[4]

Another case is recorded by Mr. Carlin.[5]

Thus, although there are to be found scattered in journals and reports a great many instances of ergotine injection, unproductive of any benefit, yet we have clear evidence of its occasional advantage. Certain cases of aneurism, as, for instance, some of the subclavian, especially on the left side, are in such condition and so placed that any more active, direct treatment is inapplicable, or fraught with considerable danger, while medicine and rest produce no salutary effect. Under such circumstances, the surgeon is glad of any procedure which seems to afford some chance, however remote, of benefit. The ergotine injection must thus take its place among the resources of surgery, but if any other means can be employed, too much time must not be wasted upon such treatment.[6] It is to be remarked that in all the successful cases, more especially in those of Langenbeck, very considerable benefit followed the first injection; hence we may conclude that, unless such advantage be quickly manifested, we may, after two or three repetitions, discontinue the plan as useless.

The formula, as used in England, may be thus given:—

Extract of spurred rye, 1 part.
Rectified spirit,
Glycerine, of each, $1\frac{1}{2}$ parts.

[1] Berliner klinische Wochenschrift, 1869, No. 12.

[2] 1 gramme is equal to 15.432 grains, so that, the dose of the extract may vary from gr. ss. to gr. iij.

[3] I have not been able to find any further report, and know not if the man entirely recovered.

[4] Archiv für klinische Chirurgie, Bd. xii. S. 1070; this case is again referred to in connection with subclavian aneurism. Dutoit's solution was made thus: Bonjean's watery extract of ergot, ʒj; Spirit, glycerine, of each, ʒiij. Langenbeck attributes the absence of symptoms of poisoning to the fact that the aqueous solution contains none of the ethereal oil resident in spurred rye. The United States Dispensatory would, in its fluid extract of ergot, have no such ingredients; that of the British Pharmacopœia, being made with ether, would include it; yet both I and others have used our English preparation without such evils as vertigo and sickness.

[5] Lancet, November 30, 1878.

[6] A case is related in the Memorabilia, No. 10, 1874, in which after a long time had been employed in the use of ergotine injections for femoral aneurism, they proved useless; a few hours' digital compression cured the disease.

Of this, from ten to fifteen minims may be injected in close proximity to, but not into, the sac.

The third class of methods, viz., those which *mitigate or suppress circulation through the affected vessel*, are by far the most important, since they are the most successful.

MANIPULATION.—The procedure first devised, practised, and named by Sir William Fergusson "manipulation," rests upon the spontaneous cure by displacement and impaction of clot—a mode which has been shown (p 405) now and then to occur. Sir William, in two well-known cases[1] of subclavian aneurism, displaced by external pressure with his thumb a certain quantity of the clot which lined the aneurisms. In the one case, pulsation in the vessels below ceased, but only for a few hours; after two attempts the tumor was unaffected, and eight months after it burst. In the other there was no change. A year afterwards direct pressure appeared equally unavailing; the man went to sea, and in yet another year came back with the aneurism solidified. Now, since displacement and impaction of clot, whether fortuitous or induced by art, must needs be a rapid, almost a sudden event, we cannot possibly ascribe the cure, verified two years after, to the manipulation, nor, indeed, to the pressure. The most important point in both these cases is, that the patients suffered certain severe, even dangerous nerve-symptoms—the former merely temporary confusion and giddiness, the latter hemiplegia; the clot had gone the wrong way, and too far, namely, up the carotid. So, also, we find two cases in which the examination for diagnostic purposes of carotid aneurism produced paralysis and death.[2] On the other hand, three cases recorded by Mr. Teale, Dr. Blackman (femoral aneurism), and Mr. Little, of Donegal (right subclavian aneurism), were successful; but in the first two, pressure having been likewise employed, the share which manipulation may have had in the cure is doubtful. Mr. Little employed no other treatment; no cerebral symptoms supervened. On the third day the vessels beyond pulsated more feebly; on the tenth, not at all. The tumor gradually solidified and ceased to throb. On this one fortunate and in no way ambiguous case we must avoid building too large a superstructure.

The mode of operating is, first, by gentle but continued pressure to empty the sac of its fluid contents, and then, with a brisk movement, to rub the two sides of the aneurism sufficiently forcibly together (Mr. Teale kneaded the femoral aneurism a good deal); and it is well to endeavor to direct any laminæ which may be detached towards the distal mouth of the tumor, if it be of the fusiform variety and have two mouths. After this has been done, the result is mere chance. It may be for good, if the loosened clot be of just the size and form to block the mouth of the sac, or if, as I suspect in Little's case, it be only semi-detached, and gradually attract more fibrin. Sometimes, as in Fergusson's case, a promise of benefit may entirely disappear in a few hours. For aneurism about the limbs, any one of the methods about to be described would be preferable, as more reliable and less likely to prove injurious. For aneurisms of the carotid no such method should be tried. There is, too, in both right and left subclavian aneurism, undoubted danger of cerebral embolus by way of the vertebrals, and in the former case by the carotid also, since a back flow of the stream probably takes place while manipulation is going on. In certain inguinal aneurisms, other means being almost precluded, the procedure may be attempted.

[1] Med.-Chir. Trans., vol. xl.

[2] Virchow's Archiv, Bd. xi.; Medical Times and Gazette, 1859, vol. i.

Compression.—The various methods of employing compression for the cure of aneurism may be conveniently divided into (1) direct compression, that is, upon the tumor itself; (2) indirect compression, that is, upon the artery above or below, these varieties being termed respectively proximal and distal; (3) general compression, that is, pressure exerted upon the whole limb; and (4) compression by means of flexion.

Direct Compression.—Of *direct compression* I shall say but little here. Heister,[1] in 1744, seems to have been the first surgeon who formulated this method, and Guattani,[2] the first who had some success, more especially in such aneurisms as occur at the bend of the elbow, a frequent sequel, at that time, of accidents in venesection. Guattani's method was more particularly by the use of the bandage and compress; Heister, the mechanical tendency of whose mind is still well known, invented various forms of tourniquet, among others a progenitor of our modern "ring-tourniquet." No doubt some of the persevering efforts which those surgeons have recorded, would have had better chance of success had they been more moderate. The endeavor entirely to empty and keep empty the sac, or totally to eliminate pulsation, led to various forms of accident, such as rupture and sloughing, and in a number of cases to refusal any longer to submit to treatment.

Four cases of cure by this means are recorded by Ciniselli,[3] Brunker,[4] Holmes,[5] and Buckminster Brown.[6]

Case XI.—Ciniselli's case was one rather of wounded carotid than of aneurism; a sponge was applied with a flannel bandage around the neck, and therefore could only have exerted very little pressure, at first for from seven to eight hours, and towards the end for fifteen hours daily. In ninety-seven days, pulsation of the tumor ceased.

Case XII.—Dr. Brunker's patient, a man aged 32, had been undergoing severe bodily labor, and was admitted into the Infirmary, August 20, 1839, with a rather large popliteal aneurism; he was placed at entire rest, with low diet. "Two days after admission, a piece of dry sponge was placed over the aneurism, and retained *in situ* by a roller rather loosely applied." On the 27th of the same month (the bandage does not seem to have been disturbed or renewed in the interval of five days), "I was greatly surprised to find the tumor much diminished in size, and that no pulsation could be discovered in it." The effect of a simple sponge-pad placed loosely on such a tumor could have been nothing, even had the bandage been kept up to its original rather loose condition; the cure—spontaneous, or by rest and diet—happened to coincide, in point of time, with the local application.

Case XIII.—In 1875 Mr. Holmes treated, at St. George's Hospital, a small subclavian aneurism by binding into the supra-clavicular space a hollow India-rubber ball of due size filled with air. Gradual consolidation took place in about eight weeks.

Case XIV.—Dr. Buckminster Brown, of Boston, applied direct pressure to a large femoral aneurism; this at first was effected by weights of from 10 to 24 pounds while the patient was in bed, and afterwards by a pad and belt while he went about and attended to his business. The aneurism was cured in six years, and the man lived nearly six years afterwards, dying ultimately from an independent disease.

It is necessary to use great caution in the selection of cases for this plan of treatment; one certainly would not recommend it for aneurisms on parts of a limb where proximal pressure or other means could be employed. In subclavian cases, one would in preference choose those cases in which the sac pro-

[1] Heister, Dissertatio Med.-Chir. de genuum structura eorumque morbis.
[2] Guattani, De externis aneurysmatibus, etc.
[3] Annali Universali di Medicina, 1867, p. 351.
[4] British and Foreign Med.-Chirurg. Review, Jan. 1840.
[5] Lancet, Feb. 12, 1876.
[6] Boston Medical and Surgical Journal, 1875.

truded upwards and forwards, and certainly would avoid those in which it extended towards the lung. Direct pressure should very rarely, if ever, be used upon the external protrusion of an intrathoracic aneurism, because it can do no good in promoting cure, but chiefly because that portion of the sac, yielding to each pulsation, serves as a sort of spring, and thus relieves internal parts from suffering the full force of the blood-wave.

When, in suitable cases, direct pressure is used, its action on the skin must be sedulously watched, and any sign of inflammation or any appearance of blood must warn the surgeon at once to discontinue its employment. Suppuration between the skin and the sac, ulceration on the surface, and, above all, a slough over the aneurism, would, in all probability, prove fatal, and would at the least be dangerous and embarrassing complications.

When flexion, indirect pressure, or ligature, having at first appeared successful by cessation of pulsation, seems about to fail by recurrence of the pulse, direct or general pressure is a very valuable resource, and no doubt many relapses have by such means been prevented. A bandage should be firmly, but not tightly, applied from the extremity to some distance above the tumor, between which and the roller, a piece of sponge, a curled horsehair pad, a half-empty India-rubber ball, or some other elastic cushion can be interposed; the toes or fingers, as the case may be, must be examined from time to time, and the absence of commencing gangrene verified.

Indirect Compression.—Indirect compression is a comparatively modern development of surgery, for although in earlier times the direct pressure just described was supplemented by the addition of a hard pad beneath the bandage, over the artery, it is clear that no definite attempt had ever been made to cure an aneurism by pressure—not on the tumor itself, but on the vessel some distance above—until Hunter had shown that a check to circulation at such a place would obliterate the cavity of the sac.[1]

Pressure then began to be systematically employed, at first, as ancillary to ligature. In the first quarter of the present century many attempts were made to cure aneurisms by this method alone; but they very generally failed, not as much because the instruments were imperfect, as because such pressure was used that it either could not be tolerated or produced eschars. The first successes belong to Dupuytren, Boyer, and Dubois. The years 1820 or 1824 (we need not follow controversies as to priority), are the time when indirect compression began, through the labors of Dublin surgeons, to take a fixed place in the resources of surgery; the names of Todd, M'Coy, Cusack, Crampton, and Bellingham are more especially connected with the various instruments, arrangements, and general regulations, which have caused this method to be other than merely a resource when nothing else could be done.

Indirect pressure is applicable to most external and to some internal aneurisms; it may be applied by means of instruments, or by the fingers of a staff of assistants. These methods are termed respectively, *instrumental* and *digital*, and both may be either *proximal* or *distal:* the latter, however, should only be used when the former is anatomically impossible; it has furnished very few encouraging results.

Both instrumental and digital, proximal pressure may be employed in one of two ways: the first, named "gradual," is intended to produce a partial occlusion of the vessel, permitting a slender stream of blood to percolate the sac, and thus, by a process somewhat analogous to that which external to the

[1] Broca labors hard to show that the primary idea of indirect compression is French. Boyer and Dubois had the first successes in 1810. Ford's and Blizzard's unsuccessful attempts were in 1788 and 1803 respectively. Freer's experiments, on which much excellent work was founded, were published in 1807.

body is called "whipping," to conduce to the deposit, layer by layer, of aetive or laminated clot. This deposit, if all proceed in the most desirable manner, should, in due course, fill the aneurism, and subsequently also the vessel itself, up to and down to the next considerable branch. Sometimes, however, the clotting in the artery beyond the sac does not occur; and it is probable that certain instances of more or less rapid relapse have been owing to non-obliteration of the afferent and efferent vessels. The gradual method may be continuous or non-continuous. In the earlier days of this mode of treatment, pressure was nearly always kept up unintermittingly, day and night, until it succeeded or had certainly failed. Of late, however, the more merciful plan of non-continuous compression is generally employed,[1] during periods, and at intervals, adapted to the powers and endurance of the patient. It is certainly wise to leave, every night, from four to six hours for undisturbed sleep.

The second method, called "sudden," or "rapid," attempts to do in a certain number of minutes, or perhaps of hours, what by the gradual method is done during days or weeks; in certain parts of the body, notably the abdomen, this is the only available means of making pressure; but it may also be used for external aneurisms. The aid of an anæsthetic (but complete anæsthesia is not needed) is usually invoked, and then by means of the fingers, or some compressor adapted to the part, complete occlusion of the vessel is effected, until, if success is to be obtained, the tumor may be felt to become solid. The pressure is then somewhat relaxed, but is not to be entirely abrogated for a period of at least five hours. For the clot which is produced suddenly, by complete stagnation of the blood, is necessarily of soft, loose consistence; a mere coagulation of fibrine and corpuscles, inclosing in the meshes a quantity of serum. After a time, this semi-solid contracts centripetally, and the fluid becomes squeezed out into the circumference, that is, between the coagulum and the sac. It is to be supposed that, if no blood-current re-enter the aneurism, this serum must become absorbed, and the sac must contract upon the already diminishing coagulum; or if a slight stream do afterwards pass through the tumor, active laminated clot may be formed around the passive one. But it may and does also happen that a relapse will occur; the newly entering blood-current dissolves or washes away the recent coagulum, and the sae is again filled simply with fluid blood.[2]

But if the surgeon find that, under proximal, rapid pressure, solidification in the aneurism is taking place, he may entertain strong hopes that by cautious management a cure may result. Some dangers are, however, yet to be considered. Broca did, doubtless, very much exaggerate the after dangers of passive clot accumulated within an aneurism, as the vast number of rapid cures by pressure and by the Esmarch bandage show; but there is undoubtedly, in these cases, a certain proclivity to inflammation and suppuration of the sac. Sometimes the effect of proximal pressure, either gradual or sudden, is the direct contrary to that which is intended, viz., a marked and rapid increase in the size of the sac. It is difficult to account for this phenomenon, but we know that it is not very infrequent, and that it is a strong warning to the surgeon to discontinue the treatment lest rupture take place. Indeed, this untoward event has occasionally occurred.

*Indirect, instrumental pressure* on the *proximal side* of the tumor has been most frequently used with success in popliteal and in femoral aneurisms, but has also proved efficacious when applied to the brachial, subclavian, and com-

[1] Sometimes called dis-continuous.

[2] This question of relapse after apparent solidification, presents a hitherto unsolved difficulty. I am not aware that any facts go to show that clotted blood can be redissolved in flowing blood; and yet we know that clots formed after the above manner in aneurisms do disappear without producing embolism of the vessels beyond.

mon or external iliac arteries, as also to the abdominal aorta. It may be carried out according to either the gradual or the rapid method. The former of these consists in the application of some instrument, generally some ingenious modification of the tourniquet, according to the vessel to be compressed and the shape of the parts, with sufficient force to greatly diminish, but not altogether to suppress, the blood-current through the tumor. Generally it is advisable to inclose the limb below the point of pressure, or, at least, below the tumor, in some soft form of bandage—Domett or fine flannel—applied either in the form of a roller, or cut into proper lengths as a many-tailed bandage. Since the treatment is not intended to effect any sudden, or indeed any very rapid changes, and since no point of the skin can bear continuous pressure for more than a short period, two places for its application are chosen, two instruments or a double-armed instrument being used, so that the localities of compression can be alternated. Many surgeons prefer, instead of the second tourniquet, certain forms of weight. Three details of management are, above all others, those that most conduce to success: (1) Regulation of the pressure, so that a continuous, slight stream may go on through the sac; (2) Avoidance (in some parts) of pressure on the main vein; (3) Great attention to preserve and keep in good condition the skin at the points of pressure.

Few conditions in surgery vary so much and so unaccountably, in different cases, as the tolerance of patients for the irksomeness of confinement to bed and the retention of one attitude. Nor must it be taken for granted that all the ordinances of the surgeon are to the letter carried out, or that all displacements of the instrument are entirely accidental. In every case, even when the patient has the best intentions, great vigilance must be exercised; for often uncontrollable restlessness, severe pain, or the exhaustion of sleeplessness, breaks down his powers of endurance. Hence, it is well to have two reliable nurses, intelligent enough to manage the instruments, who shall never leave the patient alone; better still, to have two or three steady and careful assistants, one of whom can be always on the spot, to direct the treatment.[1] The administration of anodynes and narcotics is often necessary. Chloral hydrate, bromide of potassium, and morphia, are all valuable. Aconite is especially lauded by some surgeons as lowering the action of the heart, while it also soothes nervous irritation. Belladonna, or rather atropine, is very valuable when it is tolerated. In spite of all these adjuvants, the patient's courage not unfrequently gives way, the chief causes of failure being pain, culminating in agony, irritability, and exhaustion.

*Digital pressure* is frequently preferable to instrumental pressure for brachial, femoral, popliteal, and especially for high carotid aneurisms; it is to many patients less wearing, and is less likely to produce inflammation at the part compressed. The treatment is, however, attended by many difficulties, especially if it is to be carried out away from a large town, in which a medical school may provide a sufficient staff of trained, reliable, and patient assistants. Three at least of such should always be with the patient, and these should be relieved by a fresh relay every three, or, at most, four hours. Two should be occupied simultaneously about the patient, one to keep his hand on the aneurism, and, by observing constantly the amount and mode of its pulsation, to direct another who compresses the artery. Lest he who is exercising compression should become fatigued too rapidly, a weight, either a shot bag or a moulded piece of lead, enveloped in wash leather, should be provided, which, being suspended by a cord over the bed, and laid upon his fingers, supplements and economizes muscular force. Even with this aid, the hand becomes, in the course of a few minutes, too tired and numb to efficiently compress the

[1] More full descriptions are given in connection with the treatment of popliteal aneurism.

vessel; the assistants then change places, and the second undertakes the duty of watching the aneurism, while the first becomes the compressor, and so on, alternately, until it be necessary to call in the aid of the third assistant, or to make an entire change. Of course, the place of pressure must be occasionally shifted, if the anatomy of the part render such a change possible. Under all circumstances, the condition and behavior of the skin must be very carefully watched during the whole time, and signs of inflammatory complications among deeper parts must be looked for, any such condition negativing a continuance of the treatment.

Neither instrumental nor digital pressure need be kept up uninterruptedly until the cure is complete or failure accepted. That method, called the continuous, is for most patients unbearable, or at least very painful, and, if it last long, exhausting. The interrupted mode—sometimes termed, not very elegantly, discontinuous pressure—is far more supportable, and, to judge from records, quite as successful, though, of course, less rapidly so than the most fortunate examples of continuous pressure. As the name denotes, the treatment is carried on only during a certain number of hours of the day, the night generally being set aside for repose. While the instrument or fingers are off duty, the limb, if the position of the tumor be favorable, may be kept in flexion, or simply bandaged with a pad over the sac, to make slight direct pressure. Sometimes the treatment may be altogether suspended for several days, or longer, and then resumed. If the aneurism do not grow, and if the patient's condition of health be such as to forbid more active measures, this treatment may be carried on at intervals for a very long time, and success be even thus ultimately attained. In one case of femoral aneurism (already quoted) which was treated by direct compression,[1] the surgeon began with the use of weights, and afterwards substituted pressure with a pad and belt, and let the patient move about. After six years the tumor became solid, and the patient lived several years longer.

Pressure, either instrumental or digital, may be used on the *distal side* of the tumor, as a mere adjuvant to proximal compression; or sometimes, as in aneurism low down on the carotid, as the only feasible method of treatment. Certain abdominal aneurisms may be dealt with in a similar manner, but with less chance of success, distal compression having less scientific applicability here than in the case of the undivided large trunk of the neck. It should never be employed on any other artery, save as a mere aid, if proximal pressure be possible.

*Rapid Pressure Method.*—However employed, indirect pressure by the gradual method occupies a considerable time,[2] and hence is, for many persons, inadmissible, while others will not submit to long and irksome treatment, the result of which is, to a considerable degree, uncertain. Again, some forms of aneurism, chiefly of the abdominal aorta, cannot be dealt with after this method. The *sudden* or *rapid* method of using compression was introduced by Dr. Murray, of Newcastle-on-Tyne.[3] The patient, a spare man, aged 26, was subjected to pressure, with a horse-shoe tourniquet, on the aorta, just below the margin of the left ribs, at first for two hours, without avail, and three days afterwards for five hours. During both periods anæsthesia was maintained. The pressure was such as to stop pulsation in the tumor, in the aorta below, and in the femorals at the groin. At the end of the second attempt the aneurism was found to beat much more feebly, and in a day or two it became completely consolidated. This rapid mode of compression has

[1] Brown, Boston Medical and Surgical Journal, 1875.

[2] Nineteen months is, I believe, the longest period of treatment recorded, but seven, five, and four months are not infrequent.

[3] Med.-Chir. Trans., vol. xlvii. p. 187, 1864.

been adopted, also, in other cases of abdominal aneurism, and occasionally with success.[1] Brilliant as the cure, when it occurs, may be, the method is not without danger, not only to the aneurism, but also to the peritoneum and viscera at the point of pressure.

The same means are used also for aneurisms of the limbs; indeed, since the success of the method in abdominal cases, and the occasional rapid cures by the Esmarch bandage and by flexion, some considerable modification in the views of surgeons has taken place; even the Irish school no longer so strongly insists upon the necessity of permitting the continuance of that slight stream through the tumor—that gentle thrill of the sac—which seemed to them formerly an essential. Many now prefer to entirely occlude the artery, permitting no wave to pass. If to do this a great degree of pressure is required—such a degree as even morphia will not render bearable—an anæsthetic is given, and its action maintained for several consecutive hours, as many as eighteen, with just a short interval, perhaps, for giving food; or the patient may be fed by the rectum. A certain number of persons are able to bear such pressure as will completely eliminate pulsation without this aid, even though repeated at no long intervals for eight or ten hours at a time; and after even as long a period as six months, the method may succeed or may fail.[2] I cannot say, however, that such persevering—I had almost said obstinate—adherence to one method is deserving of imitation.

General Compression.—Another method is to apply pressure to the whole limb, which may be best done by the use of the Esmarch bandage; it is most suitable for aneurisms situated some distance below the proximal joint of a limb, but may also be used as a species of distal pressure below an axillary or an inguinal aneurism.

Esmarch's bandage was first employed for the cure of a popliteal aneurism by Dr. Reid, at the Royal Naval Hospital, at Plymouth, in September, 1875, after failure of proximal pressure by Carte's apparatus. The flat elastic bandage was rolled on the limb from the toes upward to the upper third of the thigh, being wound only loosely over the tumor. The cord was then placed *in situ* to compress the vessel, and the roller removed. In 50 minutes the pain became unbearable; the Carte's compressor was then lightly and intermittently applied for some hours, but merely as a precautionary measure; for by the suppression of the circulation the aneurism had been cured, and pulsation never returned. Many cases of aneurism, more especially popliteal, have since been treated in a similar manner, sometimes successfully, sometimes the reverse.[3] Nine months after his cure, Dr. Reid's patient died of heart disease and bronchitis; the popliteal artery was found occluded for $2\frac{1}{2}$ inches by "fibrous tissue," and chiefly above the sac; the vein was pervious. Collateral vessels ran as usual, communicatiag with the artery above and below. The sac was well defined, being thicker where it joined the artery than elsewhere. The centre, and also the portion of the cavity adjacent to the vessel, were occupied by an amorphous, non-laminated, coffee-colored substance of the consistence of cheese, which showed no signs of organization, or of vascular connection with the surrounding parts. The portion of the circumference of the cavity of the aneurism opposite its mouth, was occupied by several layers of laminated fibrine. Some of these were partially separated from the others, and approximated towards the centre; the interspaces thus caused were filled with amorphous substance, which, however, was of a looser character than that already described.[4]

[1] See section on treatment of abdominal aneurisms.
[2] See case in Dublin Journal of Medical Science, 1877.
[3] Statistics will be given on a subsequent page.
[4] Lancet, vol. ii. 1875, and vol. i. 1877.

These appearances, showing that the cure had been by the method of passive clot, were very characteristic. The laminated portion of the clot had evidently been formed before the bandage had been applied, coagulation having been aided or produced by the previous pressure. Shreds of this material had become detached in the application of the flat bandage. The unorganized material was that which had been produced by the Esmarch method; it filled the part of the sac next the artery (the last portion which becomes occupied by active clot), and encased the detached part of the laminated strata. The mode, then, in which Reid's method may cure an aneurism is, if the tumor be included in the flat bandage, a combination of pressure and manipulation; but where the sac is excluded, it acts by simply stagnating the blood, and thus permitting simple coagulation. Mr. Gould[1] considers that coagulation commences in the vessel, and that to its occlusion the cure is due—a view which cannot, I think, be maintained, and which certainly has not been proved.

It is desirable to so employ the apparatus as to have the aneurism, and the vessel a short distance above and below, well filled with blood. Thus, suppose the aneurism be popliteal, the flat bandage should be applied from the toes to near the lower margin of the sac; then the patient should be made to stand, and another similar band tightly rolled on the limb from just above the tumor to the top of the thigh; then, when the recumbent posture is resumed, the round cord is to be adjusted, and the flat bands removed. Other surgeons simply bandage the limb, the patient lying down, with the flat elastic, taking care to keep the turns that encircle the sac looser than the rest. For the first few minutes this appliance is very tolerable, but after that time the part begins to be very uneasy, and then increasingly painful. Few patients can endure the pressure for more than half an hour; but this inconvenience may be partially obviated by beginning with a narcotic, or entirely eliminated by ending with an anæsthetic. The limb should be kept pulseless, unless circumstances forbid, for an hour; but, during that time, the extremities, fingers or toes, must be watched, lest gangrene should suddenly supervene; the state of the circulation generally should also be sedulously attended to. Before the cord is removed, a tourniquet should be placed on the artery above, and screwed down sufficiently to command the stream and prevent a sudden flow into the sac, which might carry away the soft recent clot; or the same end may be obtained by digital pressure. After removing the cord, the surgeon may, while keeping his hand on the tumor, let an assistant slowly relax the pressure, while he watches for pulsation; even if no, or, *a fortiori*, if a slight wave appear, compression should be continued for at least two hours. If, at the end of that time, some thrill remain, the artery must be still restrained; indeed, the case may be regarded as one to be treated by proximal pressure, the first impulse towards consolidation having been given by the Esmarch cord; or, on the other hand, a second application of the bandage and cord may be deemed desirable. The choice must be regulated by the result of the previous application, and by the effect of the proximal pressure. If the former have produced a certain amount of clotting, which has not dissolved away, the probability is that some little continuance of pressure will effect a cure. If, on the other hand, the elastic pressure have produced no clot, or a very transitory one, the choice lies between recommencement, *ab initio*, of the whole proceeding, or abandoning the method altogether, and resorting to some other means. Herein the surgeon must be guided by the manner in which the previous pressure has been borne, and by the general results of repetition, which will be hereafter given.

If it be determined to use the Esmarch cord again, I would strongly recom-

[1] Lancet, vol. i. 1877.

mend that, unless urgency of symptoms forbid, an interval of from five to eight days should be allowed, during which time such treatment as tends to produce coagulability of the blood may be employed,[1] such as, for instance, the dry diet and low diet system (p. 410).

A consideration not to be disregarded is the state of the heart and its valves, and of the aorta immediately adjoining. It has been suggested, rather than proved, that application of the Esmarch bandage, whether for aneurism or for other cause, might, by over-filling the rest of the circulation, prove dangerous to one suffering from valvular incompetence, or from weakened and dilated aorta. Mr. Gould has suggested that these perils might be obviated by placing a round elastic cord around the other limb, so as to imprison its blood within its vessels. It is difficult, however, to perceive how such an expedient could have the desired effect, since the limb must contain the same amount of blood, whether it be stagnated or no, and the rest of the system, therefore, is not relieved by any withdrawal of circulating fluid, while the vascular system loses the resiliency of the limb vessels—to a certain extent a safeguard against the accident dreaded.

It is evident that the mode in which the Esmarch bandage acts is by mere stagnation. The blood in the aneurism, and in the vessel immediately leading to it, is kept at entire rest; and if it be of such a quality as to easily coagulate, it will do so to a certain extent. The clot thus formed in an hour, or, perhaps, in two, is exceedingly soft, and its cohesion is almost *nil*. Hence pressure must prevent any flow of blood into the artery, and great quietude must obviate any tendency to detachment. It has not unfrequently happened that, when all these precautions have been observed, and when the aneurismal tumor, not pulsating, has appeared completely solid, the condition in the next twenty-four hours has been quite reversed; pulsation has recurred, no sign of any remaining clot has been found, and the aneurism has appeared larger, nearer the surface, and more thinly walled than before. In certain cases, death has resulted; in a few, gangrene.

COMPRESSION BY FLEXION.—The *Écho Médical Suisse* reports in its number for September, 1858, an interesting case of popliteal aneurism, which, a year previously, had been under the care of M. Maunoir, of Geneva. That surgeon observed, during his examination of the tumor, that when the limb was bent, pulsation ceased. Acting on the lines thus indicated, he did not even order the man to bed, but applied a sling in the daytime, and a bandage at night, in such wise as to keep the limb constantly flexed. In a few days the pulsation had greatly decreased; in about eighteen the tumor was solid. A year afterwards, when the above paper was published, only a small, very hard lump remained in the ham.

By one of those singular coincidences which rarely occur, it was in that month, September, 1858, that Mr. Hart observed in a case of popliteal aneurism a like diminution of pulsation on flexion of the limb. He treated the case on this hint by keeping the man's limb bent,[2] and in about five days the aneurism was solidified. This result led to frequent imitations of the practice, and occasionally with very good effect. It is more especially adapted to aneurisms about the bend of the elbow or in the popliteal space; in other localities it has not been equally successful. The method has also very frequently failed, nor is it entirely devoid of danger. The sort of aneurism in which it is most likely to be valuable, is a small, sacculated tumor whose strong tendency to spontaneous cure is marked by a thick, hard sac, situated either at or just below the ginglymus in the middle of the limb. One or two

[1] Mr. Gould recommends this in all cases.

[2] Med.-Chir. Trans., vol. xlii. p. 205.

such cases have been cured by mere voluntary flexion in bed. The surgeon may judge if it be advisable to try this mode of treatment by observing whether bending of the limb produce any diminution of pulse; if not, the employment of this method is probably unadvisable. Powerful, or indeed any flexion beyond a very moderate amount, ought not to be attempted, even for experiment, on large, thin-walled aneurisms, since rupture has more than once followed such an incautious proceeding. Over-zealous and too persistent efforts at cure by this means occasionally injure the joint subjected to flexion.[1]

On the Choice of Cases for Different Forms of Pressure.—We may now advantageously pause to consider the advantages and disadvantages of these different forms of pressure, especially for aneurisms about limbs, as also the cases in which they are severally most applicable. It is of course to be understood that the surgeon undertaking to treat a case by these means does not limit himself to the use of one form alone, but will vary or alternate his resources according to circumstances.

*Flexion*, which is but a mode of pressure, is most successful for aneurisms situated at or below the middle joint of the limb; it probably combines in one, proximal, distal, and direct pressure. It should never be used for a large aneurism in the bend of the hip-joint, lest it rupture the sac. It is not a very potent means of treatment, that is, it will not, or at least will very rarely, benefit an aneurism with thin walls which is still increasing; but if the disease have already considerable tendency to spontaneous cure, that is, if the tumor be hard, and have barely increased for some little time, flexion even very moderately applied may cause consolidation. I have known of more than one popliteal aneurism, the tendency of which to cure was so great that mere rest in bed, with the knee voluntarily kept bent by the patient, has given to nature all the necessary assistance. In choosing the treatment to be applied in any case, flexion suggests itself among others to the surgeon; but I would not recommend this method, unless it should be found that a not excessive degree of flexion stopped pulsation of the aneurism, entirely or in great part. The method may also be used to assist other forms of treatment, as sometimes simultaneously, or better alternating, with indirect pressure, or in recurrent pulsation after ligature.

*Indirect pressure* (*gradual*) is also most likely to succeed when a tendency to spontaneous cure is manifested by some accumulation of clot in the sac. The greater the amount of consolidation, that is to say, the harder the tumor, and the more distant the pulsation, the more likely is cure to follow upon pressure. It is not intended to assert that, if the evidence of clot be small, failure must necessarily result, but it is probable that success if attained at all will be long postponed. Before commencing such treatment, we must weigh the probable duration by the above scale against the character of the individual. To employ pressure in the case of an irritable person; of one habitually restless and unable to bear confinement, or to remain long in one position; or of one who is impatient of pain and discomfort, while intolerant of sedatives, would be to court failure. For such persons the *digital* is preferable to the *instrumental* method, the presence of other persons, and the diversion of talk and of constant changes, distracting thought from the sense of discomfort. The frequent intermission of a night for untrammelled sleep and quiet is generally, if the cure be protracted, advisable.

The *rapid method* of treatment by compression is more especially adapted to abdominal aneurisms, whether of the aorta or of the iliacs; to high femoral (inguinal), and, perhaps, to carotid aneurisms—that is to say, to cases in

[1] For further directions as to this method, see popliteal aneurism.

which the tumor is so situated, that either much force is necessary to command the artery or, that the pressure by its mere situation is unbearable. It has also been now and then successfully employed for aneurism about a limb, when the patient, either from constitutional irritability or from recalcitrance, could not, or would not, submit to the pain and restraint necessary for the slower method. In one or two cases a combination of morphia and chloroform has been used as an anodyne, instead of the latter alone.

The *Esmarch bandage* answers best in cases of recent aneurism; nor do I think the presence of clot so great a desideratum as for the treatment by flexion or indirect pressure, though certainly it is no disadvantage. From my experience, I should say that aneurisms of recent formation, which are steadily, but not rapidly, increasing, and which have forcible pulsation, and walls neither markedly thick nor peculiarly thin, are those most amenable to this form of pressure. It should not be employed for large, thin-walled tumors, nor on persons whose arteries are rough and rigid, nor on those with diseased heart,[1] nor on such as have a tendency to either pulmonary or cerebral congestion. For all forms of compression, long fusiform aneurisms are peculiarly ill-adapted.

THE DEFECTS AND DANGERS OF COMPRESSION.—The intention and object of treatment by the various forms of compression are, the avoidance of cutting operations with their risks and other drawbacks. This method was more especially studied and introduced at a period in surgery when such operations, in the absence of anæsthetic agents, were extremely painful, and when the management of wounds, and the presence in them of hempen or silken cords, rendered the tying of arteries a dangerous procedure. But we are not to suppose that any form of compression for aneurism is free from certain very grave objections, which ought always to be present to the mind of him who would thus attempt to cure the disease.

Every form of compression (flexion is included) is *painful;* sometimes, however moderately used, unbearably so—hence the use of narcotics, which some persons, up to a certain point, tolerate well. If the treatment be protracted, it is extremely irksome and wearing, the patient losing both health and strength. The *length of time* during which such treatment may last is very considerable; and although many aneurisms have been cured in from ten, or even less, hours to four or six days and onward, a large number have been thus continuously treated for several months, and in such cases a goodly proportion of the patients have failed to derive any permanent benefit[2]—a most disappointing result of painful and persevering efforts. A certain tendency to *relapse* remains after apparent cure by pressure. Sometimes this is rapid—that is, within twenty-four hours—sometimes slow, or not till after some weeks. Doubtless this is due to consolidation of the aneurism by soft clot, while the artery remains patent, the blood-stream breaking down and carrying away the partially coagulated blood.

Nor must we consider that pressure is entirely free from *danger*, even when carefully and skilfully employed. We have seen (p. 422) that an occasional immediate effect of proximal compression is rapid enlargement of the sac—a phenomenon which points to the possibility of its producing *rupture*; a possibility, too, which has once or twice been exemplified by actual occurrence. This danger, doubtless, is most imminent in the use of flexion and the Esmarch bandage. *Gangrene* of the limb below, is an event common to all forms of treatment, and, indeed, to all forms of the disease; it may, in some cases, be

[1] Aortic incompetence and mitral stenosis are peculiarly unfavorable.
[2] Statistics will be given hereafter.

due to pressure on the vein rather than on the artery. *Suppuration of the sac*, especially when the cessation of pulsation has been rapidly produced, must not be left out of sight. *Erysipelas*, with gangrene at the place of pressure, has in some instances followed moderate compression.[1] Even *pyæmia*, although no external wound has been produced, may result;[2] while Mr. Savory's well-known case shows that *thrombosis* with solidification of the lung, may also follow; and Mr. Pemberton[3] gives an instance of the production of *arterio-venous aneurism* at the seat of compression. It is not intended to assert that these accidents are common, or even otherwise than rare, but they must be taken into account; for we have, when we propose to subject a patient to any form of pressure, to consider the possibly protracted treatment, the very considerable uncertainty, the tendency to relapse, and the occasional occurrence of severe, or even of fatal complications.

Another point deserving of very careful consideration is the state of the vessels after the failure of compression, and whether they are left in a state more or less favorable for the application of a ligature. I think that some of those who have expressed themselves on this subject have attempted to answer the question on too broad a ground, and on too general principles. We may, first, consider the result of *proximal pressure*, digital or instrumental, applied for a moderate time, and so as to produce no obvious lesion. If such treatment have been employed, for instance, on the femoral artery, at and a little below the groin, there is no doubt that the collateral vessels will have become enlarged; but this is, in many cases, a detriment rather than an advantage, and may lead to such free flow of blood by the side arteries into the sac, that pulsation rapidly recurs after ligature, and no consolidation occurs. Therefore we may affirm that in persons whose arteries are rigid, either from age or other causes, the effect of pressure on a subsequent deligation, will, undoubtedly, be beneficial, as tending to diminish the risk of gangrene; but that in persons, whether young or old, whose vessels are not stiffened by atheroma or calcification, the effect of unsuccessful pressure will be to jeopardize the result of subsequent ligation, by permitting, through the enlarged collaterals, too ready an influx of blood into the sac.

The same may be said concerning failures of *flexion*, and there seems, moreover, to be, under such circumstances, a considerable tendency to suppuration or rupture of the sac, when recourse is afterwards had to ligature. When, the *Esmarch bandage* proving useless, deligation is employed, there seems also to be some tendency to suppuration of the sac, but the especial danger is gangrene. Unless rapid growth of the aneurism should render immediate measures necessary, some days should elapse between the abandonment of Reid's method and the application of the ligature, in order to allow the vessels, which have been somewhat rudely closed, to recover their elasticity. The artery should not be tied at the spot to which the cord has been applied.

When any form of pressure has produced gangrene of distal parts, the application of the ligature, which will be a necessity if the aneurism continues to enlarge, increases the area of sphacelus.

When gangrene of the soft parts at the place of pressure has resulted,[4] no

[1] Gay, Subclavio-axillary Aneurism, Lancet, Feb. 10, 1872.

[2] Bulletins et Mémoires de la Société de Chirurgie de Paris, quoted in Lancet, Jan. 15, 1870.

[3] Med.-Chir. Trans., vol. xliv. p. 189.

[4] A certain number of patients cured by proximal pressure, have suffered from gangrene invading the tissues pretty deeply at the spot compressed. Others, whose integuments have become gangrenous, have not been cured. I consider that to carry treatment thus far is improper; if the case be not cured, or if, as has sometimes happened, a rapid relapse take place, the patient, with a slough over the artery, is in very great peril.

ligature should be applied at that spot; but the vessel must be tied above and below, the ligatures being separated as far as possible without any large branch springing from the artery between them. If this cannot be avoided, the branch must also be ligatured. Even if no gangrene, but pretty severe inflammation of the compressed soft parts, have arisen, deligation of the vessel, at that point, should be avoided.[1] After the use of pressure for some considerable time, the artery is not unfrequently found to be so imbedded in thickened tissues with which its outer coat is continuous, that it is difficult to pass an aneurism needle around it. In some cases, the vein has been very closely adherent to the artery, rendering isolation and deligation exceedingly difficult, and even dangerous.

In conclusion, I would say that since certain operative improvements and the use of soluble ligatures have rendered the operation of tying arteries a far less hazardous measure than it was some years ago, the treatment by pressure ought not to be greatly prolonged, nor repeated again and again after relapses. Valuable as is this method, and desirable as it may be to avoid the knife when feasible, the effects of prolonged pressure-treatment on the health and on the limb are far worse, and no less dangerous, than ligature, while they jeopardize the results of that more potent expedient.[2] A decision as to the time when failure of compression must be acknowledged, should be founded on the length of time already consumed, and the condition of the tumor. If a few hours have produced some appreciable and real improvement, hope of success may justify perseverance; but if, while the time is longer, the change is less marked, or if complete relapse have occurred a second time, it will be wise, in the large majority of cases, to desist. The collateral branches will have probably already taken upon themselves too much work, and the state of the main vessel will be unfavorable for the further continuance of treatment.

LIGATION.—The first description of tying vessels for aneurism dates from the third century, as far as we know from the writings of the ancients preserved to us; and there is a procedure indifferently called the "old operation," or the "method of Antyllus," much talked of and occasionally practised. But, in truth, Antyllus did not describe that which is now done under these names. The only record which remains of the writings of this surgeon, is to be found in the medical collection of Oribasius, the twentieth chapter of whose fourth book is "upon aneurism, taken from Antyllus."[3] We must, in studying this method, remember that the idea of surgeons up to the end of the fifteenth century was that the solidified blood in the sac was the peccant condition—that which rendered the malady dangerous—and that the aim of Antyllus was to get rid of this without causing dangerous hemorrhage. Therefore, after distinguishing between aneurisms arising from dilatation and from rent (probably fusiform and sacculated), he says:—

"If it be an aneurism by dilatation, we make through the skin an incision in the direction of the artery, and separate its lips by means of hooks; then we divide all the

[1] Gangrene of arterial coats is very rarely, if ever, produced by pressure; but cases have, to my knowledge, occurred, in which secondary hemorrhage from the place of ligature (when applied as forbidden in the text) has set in more rapidly than could have happened had the vessel been uninjured.

[2] I would refer to the history of a case recorded in the Dublin Medical Journal, vol. lx. p. 391. The aneurism was popliteal; the patient, clever and not indocile, again and again protested against continuance of the various forms of pressure, which, nevertheless, were kept up for 720 hours spread over about a month; then the sac sloughed and amputation was needed to save life. It seems to me that such perseverance is a sacrifice to the Moloch of an idea.

[3] The work does not pretend to be more than a collection from a great number of previous writers, Antyllus, Galen, Ruffus, and many others.

tissues that lie between the artery and the skin; we separate the vein from the artery with blunt hooks, and so we uncover all the dilated part of the artery; then we pass under it a probe with a rounded end, and raise up the tumor. After that we glide along the probe a needle armed doubly with thread, cut the thread close to the needle, so that there are two threads and four ends."

These are then tied, the one above, the other below the dilatation.

"We afterwards open the tumor by a little cut on its middle, so that all its contents may be evacuated without danger of bleeding. But this manner of separating the artery and isolating the aneurism is difficult, and often the force and power of the pneuma drives off the threads. If the aneurism originate in a rent of the artery, we grip in the fingers as much of the aneurism as we can, together with the skin, and we pass under the part so held a needle with a double thread, either of flax or of tendon (ἢ λίνου ἢ νευρὰν).[1] After pushing through the cord we cut it close to the needle, so as to leave two strings."

These are tied above and below the tumor, which is then incised and evacuated, its greater portion, except that included in the thread, being removed together with the skin; "and thus it is done without bleeding."

The procedure which our writers[2] on aneurism term the "old operation," and wrongly attribute to Antyllus, is entirely different, inasmuch as in the method still occasionally practised, and which Mr. Syme tried to revive, the sac is opened before tying the artery, which is sought for from within. The procedure is this: The artery is compressed above the tumor sufficiently to annihilate all pulsation; the surgeon cuts through and turns aside soft parts until he reaches or closely approximates the sac, which he opens (or, if the tumor be superficial, he may open it at one cut); he then clears the clot away, and feels for the opening into the vessel, into which he passes a probe. This is to act as a guide to enable him to extend his incision, and to tie the artery above. He then seeks the vessel below, and treats it in a similar way. Afterwards the clots are more entirely cleared away, and the wound is loosely stuffed with lint, charpie, or tenax, and left to suppurate or to slough.

Occasionally, even now, as will be seen when we come to speak of special aneurisms, an operation closely resembling this proceeding is the only means of saving life, and, if the patient escape the exhaustion of the after processes, the aneurism certainly is fully and permanently cured. It is most often applicable in that form of wounded or ruptured artery which is injudiciously named diffuse traumatic aneurism; occasionally when the usual deligation has failed; or when after such an operation, or after flexion or pressure, the sac of the aneurism has burst. But the labors of more modern surgeons, principally directed by Harvey's discovery of the circulation, which led to the perception that the clot in the sac was not a dangerous, but, on the contrary, a salutary condition, have gradually modified the use of the ligature in many ways.

Deligation in the continuity of an artery affected with aneurism, is described as *proximal* (between the tumor and the heart), or *distal* (beyond the tumor). The application of a proximal ligature close to the sac of the aneurism is called the *method of Anel;* its application at a considerable distance, so that one or more branches are given off between it and the sac, the *method of Hunter*. The two differ essentially in their conception and physiological effects. Wherever possible, the latter method is at the present day employed; but in certain localities, as in certain aneurisms of the carotid, subclavian, or

[1] This word may also mean nerve, cord, or the string of a lute. I translate it tendon. Bussemaker and Daremberg, the translators of Oribasius into French, render it "boyaux," thinking, probably, of catgut.

[2] Except Broca, who has noticed the dangerous and painful operation above described.

external or internal iliac, it may be anatomically impossible to place a ligature at any considerable distance from the sac.

Anel[1] performed the sort of deligation which bears his name in 1710 for an aneurism at the bend of the elbow; he says, "I ligatured it (the artery) as near to the tumor as possible." This operation, not being dictated or supported on any scientific basis, attracted, though followed by brilliant results, little attention, nor does it seem to have been employed for any but small arteries[2] up to 1785, when Desault tied for popliteal aneurism the artery of that name just above the sac. Doubtless the success of that case, and it must be remembered that the cure of aneurism was at that date exceptional,[3] would have led to further attempts with Anel's method of treatment, but that in December, 1785, a patient with popliteal aneurism fell under the care of John Hunter, who, in that same month, subjected him to the new operation which has since been termed the Hunterian method.[4] Anel's plan, indeed, seems never to have taken any place as a remedy for aneurism of large vessels, and would probably have been forgotten but for the work of Paul Broca.

Now the inherent defects of ligaturing an artery close to an aneurismal sac are many. First, the vessel may at this spot be very deep; second, it is generally very considerably displaced; third, it is (save in recent, traumatic cases) nearly always diseased at the point tied; and fourth, the circulation in the sac is by this operation too completely cut off and suppressed.

The first of these objections may be left for consideration on a subsequent page, as, indeed, may also, to a certain extent, the second: it need only be remarked here that, unless the aneurism be fusiform, the vessel immediately above may be so covered by the sac as to render deligation at that spot impossible. A large popliteal aneurism, for instance, may so fill the whole popliteal space that no part of the artery is accessible between the tumor and the adductor magnus; and it has more than once happened that a proposed deligation of the subclavian has had to be abandoned, because the operator found the vessel so covered by the sac as to be out of reach. Even if this be not the case, displacement of the artery to one side, or into abnormal depths, not only renders the operation very difficult, but invests it with some little uncertainty.

Since spontaneous aneurism, in the third place, usually arises in consequence of arterial disease, the reverse proposition also holds good, namely, that in the neighborhood of aneurisms arteries are likely to be diseased; and this probability is increased by the fact that the change in circulation—the altered condition of parts around—conduces to arterial inflammation. A ligature applied to a diseased artery causes very readily ulceration and destruction of its coats before adhesion and other changes in the interior of the vessel have sealed it and made it secure; hence, secondary hemorrhage is an imminent danger after tying such vessels, perhaps even now; but it was much more so when silk or other non-soluble ligatures were used.

It has, fourthly, been frequently mentioned that the formation of a firm laminated clot depends upon the persistence of a gentle current through the aneurismal sac; but a ligature applied immediately above that spot must

[1] Suite de la nouvelle méthode de guérir les fistules lacrymales. Turin, 1714.

[2] Heister in his Institutiones Chirurgicæ described Anel's procedure, and recommended its application to "reducible aneurisms," whence we may conclude that he, like Anel, considered "that the blood contained in the sac would be dissipated, being allowed to pass on towards the extremity."

[3] I need hardly refer to the now well-known phrase of Pott (Chirurgical Works, vol. iii. p. 220), "I have tried it [Antyllus's operation] more than once or twice, and I have seen it tried by others, but the event has always been fatal."

[4] Hunter had long been cogitating the matter, and had by experiments on animals convinced himself of the truth of the principles on which he founded his method.

evidently prevent even the smallest afflux from above, while, if any return current comes to it from below, that flow must be very small and uncertain; the tendency, therefore, after cure by this kind of ligature, will be to the formation of passive clot; or, if, as may also happen, the aneurism remains empty, or nearly so, there is no material which, becoming solid, can obliterate the sac. This seems, on one or two occasions, to have occurred in some fatal cases of popliteal aneurism. In December, 1785, Mr. Hunter, who had long been considering the subject of popliteal aneurism, and the ill results of the prevalent treatment, put in practice his idea of ligaturing the vessel at a considerable distance from the sac,[1] namely, in the space between the adductors, which has since gone by the name of Hunter's canal. In the state of knowledge existing at that time, surgeons were disinclined to trust to a single ligature around the vessel, and Hunter, in this, his first case, used four strings at different intervals, and tied them loosely—hoping that by compressing so large a portion of the artery he might "make up for the want of tightness, as he chose to avoid great pressure on the vessel at any one point."[2] The aneurism was cured, but the man suffered from abscess at the site of operation, which arose partly from the locality chosen—deep among muscular and tendinous structures — partly from the kind and number of the ligatures. Shortly after this, Mr. Birch tied a man's femoral artery with "a strong flat ligature," leaving under the artery another, called the ligature "of reserve." The man died of suppuration of the sac. In his second case, Hunter used but one ligature. Certainly in some, probably in all, of these early cases, the vein was tied with the artery.

About this time[3]—the exact date cannot be fixed—Brasdor had proposed placing a ligature on an artery on the *distal* side of the aneurism, and in 1799, Deschamps performed this operation for a high femoral aneurism, with a fatal result. The younger Brasdor, son of the surgeon who proposed this method, was present, and Deschamps speaks of the proposal as "having been made a long time ago," and adds that Desault thought well of it. It is probable that this "long time" was not more than ten or fifteen years. Some time afterwards, Astley Cooper performed a similar operation with temporary benefit, but ultimately fatal result. In 1815, Hodgson[4] insisted on the necessary element of success for distal deligation being the absence of any "branch originating from the aneurism, or from the artery below the aneurism," and above the ligature, and this principle was still more strongly emphasized by Wardrop in 1825. Brasdor's recommendation, and Deschamps's and Cooper's practice, were evidently founded merely on an evasion of mechanical difficulties, in this wise: that when an aneurism was situated on an artery so high up that no ligature could be used above it, the surgeon should try the effect of tying it below; but the essential point, the

[1] In 1793, Deschamps published his "Observations sur la ligature des principales artères des extrémités à la suite de leur blessures et dans les anévrismes, particulièrement dans celui de l'artère poplitée, dont deux ont été opérés suivant la méthode de Jean Hunter, Chirurgien Anglais." It is, therefore, rather astonishing to find M. Broca, in 1856, claiming this method for Desault, on the strength of his having tied a popliteal artery within the popliteal space, and close to the sac; nor is it possible to repress a smile at this sentence used in describing another case: "With an abnegation, which his English detractors have not been able to appreciate, that great surgeon [Desault], who at that time was aware of the operation practised by Hunter, did not hesitate to adopt the precepts propounded by his illustrious rival." That is to say, before knowing of Hunter's method, he operated after the manner of Anel; after knowing of it, after the English method, or that of Hunter.

[2] Home, London Medical Journal, vol. vii., 1786, p. 391.

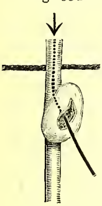
[3] Observations et Réflexions sur un Anévrisme vrai de la partie supérieure de l'artère femoral, par le citoyen Deschamps. Receuil périodique de la Société de Médecine de Paris, tom. v. 1799.

[4] Diseases of Arteries and Veins, p. 302.

absence of a branch between the ligature and the sac, was not even considered until first Hodgson and then Wardrop formulated that necessary condition.

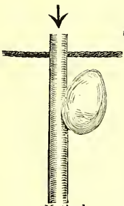
We may now judiciously pause a while to consider the different methods of ligaturing arteries for aneurism; they are depicted in the annexed woodcuts (Figs. 534–538).

Fig. 534.



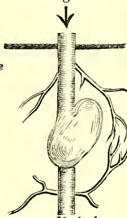
Method of Antyllus.

Fig. 535.



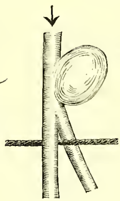
Method of Anel.

Fig. 536.



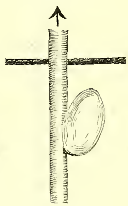
Method of Hunter.

Fig. 537.



Wardrop's "New Operation."

Fig. 538.



Method of Brasdor.

[A good deal of confusion in reference to the nomenclature of the distal operations for aneurism, is due to the fact that while, in his original paper,[1] Mr. Wardrop followed Hodgson in laying stress upon the importance of having no intervening branch between the aneurismal sac and the ligature, in his later monograph[2] he suggested his "new operation," which consisted in the application of the distal method even when such an intervening branch was present, and his famous operation on Mrs. Denmark (case of innominate aneurism) was based upon this principle.]

Hunter's operation for popliteal aneurism was received throughout the surgical world with little less than enthusiasm, and nowhere more warmly than in Italy, where Scarpa, a man of great talent, modified the procedure by tying the vessel still higher in the limb—just where it becomes covered by the Sartorius muscle, at the apex of a space which, on account of his description of it, goes by the name of Scarpa's triangle.

The question of the form of ligature, and whether it should be loosely or tightly tied, or whether the coats of the vessels should be protected by the interposition of a roll of linen or other substance, remained a matter of controversy, and, therefore, of uncertainty, until Dr. Jones published his well-known work.[3] The appearance of this much quoted, but little read book, marked an important era in Surgery; it must be again referred to, but at present I only wish to point out that its author proved by experiments that the received doctrine of occluding large tracts of the vessel was erroneous, and that the sealing of an artery depended upon division of its two inner coats, followed by their inflammatory adhesion. He even went so far in his reliance upon this adhesion as to inculcate,[4] and his teaching was borne out by experiment, that immediately on tying the vessel, and dividing its inner coats, the ligature should be removed, and the wound closed and allowed to heal by the first intention; his object being to eliminate the dangers of suppuration in the

[1] Medico-Chirurgical Transactions, vol. xiii. p. 217.

[2] On Aneurism and its Cure, by a New Operation London, 1828.

[3] A Treatise on the Process employed by Nature in suppressing the Hemorrhage from Divided and Punctured Arteries; and on the Use of the Ligature. 1805.

[4] Op. cit., 135.

wound, and of slow erosion of the remaining coat. In this somewhat bold proposition, though it found, as we shall shortly see, imitators, the surgical world did not follow him; but the ligation of arteries was much simplified, no other substance, either foreign or natural, in the immediate neighborhood of the vessel, being included in the noose. The almost universal practice was to tie the vessel tightly, and leave one end of the ligature hanging out of the wound. The inconvenience of this foreign substance, acting like a little seton, was felt. Sir Astley Cooper tried a ligature of catgut, in hopes that it might be dissolved or incorporated with the living tissues; his first case succeeded, the wound healed, and nothing more was seen of the ligature; but his second case proved disastrous, and he reverted to the use of the hempen or silk cord.[1]

Having now brought the history of tying arteries down to a recent period, we will leave retrospect, and consider the effects of an Hunterian deligation upon the aneurism, upon the vessel, and upon its branches.

We have seen that if an artery is occluded by the ligature immediately above the sac of an aneurism, all blood is cut off from entering the cavity save a slight and very uncertain recurrent eddy; but that when a considerable branch, or several smaller branches, spring from the obstructed vessel between the ligature and the sac, a very different state of things obtains. Let us take a very simple instance: a popliteal aneurism for which the superficial femoral artery has been tied a little below the origin of the profunda. At the moment of drawing the noose tight, the aneurism ceases to pulsate, becoming generally rather smaller and softer; the next effect of cutting off so large an effluent from the parent stem (common femoral), is that more of its current must be thrown on the other channels, especially on the profunda with its circumflex and other branches. The anastomotic channels between these offsets and the derivatives of the superficial femoral below the ligature, permit a certain and a gradually increasing quantity of blood to find its way into that vessel between the ligature and the tumor, and thus a gentle current through the aneurism is soon established, that is to say, the very condition which is most conducive to the steady and gradual deposit of active clot is brought about. By the time that the sac has become filled by this material, the anastomoses in the side channels have so enlarged that blood is carried freely along them to the leg below; even the diminished stream in the tied artery is no longer necessary in maintaining the circulation; and the artery very often becomes occluded by coagulum from the ligature to the aneurism, and beyond it, to the first large branch below, while in other cases a certain portion of that length remains pervious. After a little time the aneurism and the obliterated vessel undergo a process of contraction and absorption, so that they come to resemble a solid cord with a knot on it; and, after a still longer interval, very little or no trace is left of the disease. In the mean time, if a silk or hemp ligature has been employed, the outer coat—the only one really included, since the others have been ruptured and have retracted—must undergo a process of ulceration and division, so as to release the loop of the ligature; the first event is cell proliferation around it—nature's attempt to encapsulate the foreign body. The thickening thus caused, under the continued irritation, soon breaks down into pus, which collects around the artery and in its sheath, and, tracking along the course of the ligature, flows from the sinus-like wound. At first this pus is laudable, but usually, after about ten days, it gets a little stained from admixture of blood; then, in from twelve to twenty days, the continuity of the vessel

[1] Whether Antyllus used some sort of intestine, or another animal substance, is, as we have seen, doubtful, p. 432.

is interrupted, and the loop of the ligature may be pulled without any force from the opening—after which the wound ought rapidly to heal.

All these circumstances—the cessation of pulsation, partial collapse of the tumor, establishment of collateral circulation, lamination of clot in the sac, obliteration of a certain segment of the vessel, and, with some ligatures, severance of the artery—are what should take place, and what we hope for when we perform these operations. The symptoms of these occurrences are as follows:—

Almost immediately after the tumor has ceased to beat, the limb about and below the seat of ligature becomes rather warmer, and usually bedewed with a gentle perspiration. This is ascribed to retardation of the blood stream in the capillaries, consequent on elimination of the propulsive action of the heart. I do not feel much faith in this explanation, because, if the warmth depended upon a partial blood stasis, it should be most marked, or at all events should commence, at the extremity. The contrary is the case: the fingers or toes of a limb whose main artery has been tied, are cold almost immediately after, while the central and upper parts are warm.[1] The warmth may continue for many days; sometimes, indeed, it is continuous, and is accompanied by a slight surface-blush. Generally, in an hour or two the warmth declines, and the limb becomes colder than the rest of the body. These caloric phenomena and their irregularity depend upon the greater or less rapidity with which the blood is driven through the arterioles and capillaries.

After a period also depending on the quicker or slower development of the smaller blood-streams, a numb sense of formication, sometimes amounting to pain, is felt. The extremity, often the whole limb, tingles, and indeed occasionally patients will volunteer the statement that they feel as if insects were running about in the depths of the part. The person has a great sense of weakness in the limb, and does no doubt (as has been seen in experiments on animals) lose power. After a further interval, again depending upon the state of the vessels, and upon the height at which the artery was tied, these sensations more or less gradually decline and disappear. The last to entirely vanish is usually the sense of weakness; the first, unless gangrene set in, is the irregularity of temperature.

The tumor, which at first, on cessation of its beat, became both smaller and softer, continues to diminish, but soon hardens, and in a certain time (from one to twenty hours) may be felt to be quite hard and elastic, sometimes moveless, sometimes having a slight undulatory pulsation, and in other cases (in from twenty to sixty hours) possessing distinct but hardly expansile pulsation,[2] which after another interval of a few hours again disappears. If previous to operation the aneurism caused pain by its pressure, alleviation is in some cases immediate and almost sudden, but in others is more gradual. Diminution in the size of the tumor is continuous until the swelling entirely disappears, and the period of such disappearance, since it results from absorption of the laminated clot, evidently must depend on the previous size of the aneurism.

These phenomena occur if the conditions have throughout been favorable, but certain circumstances may immediately or more remotely interfere with their sequence, and with the ultimate result, namely:—

[1] I tied the right subclavian of J. S. His fingers became cold almost at once, while for three inches below the elbow the limb was abnormally warm. I made a similar observation on the person of C. M., for whom I tied the superficial femoral. The limb, including the upper fourth of the leg, was, two and a half hours after the operation, hot; below this it was less so, and at the ankle cool, the front of the instep and the toes being cold. This coldness of the toes I had remarked immediately after the operation, and had ordered a foot warmer to be placed in their neighborhood.

[2] We are here considering the occasional recurrent pulsation which is not incompatible with success.

Anatomical abnormity; excessive freedom of collateral circulation; and vascular rigidity, preventing expansion of side branches.

(1) *Anatomical abnormity*, such as the existence of a double vessel, or a high division of the primary trunk, may at once interfere with the result of operation, by causing continuance of pulsation in the tumor after the ligature has been tightened; or, as has sometimes happened, though the pulsation may cease, and all be considered well, it returns in a few minutes, or in an hour; the aneurism does not solidify; and, if not further treated, it continues to grow.

(2) A similar but generally less rapid recurrence of pulsation and failure of treatment may result from *too rapid enlargement of the side channels*, which indeed may be already excessively developed, either from natural formation, from the check to normal circulation produced by pressure of the tumor, or from the unsuccessful application of indirect compression. We may therefore, after deligation, form the following conclusion: If the recurrent pulsation has commenced after the first hour, and not later, or not much later, than the twentieth, if it remains slight and hardly expansile, and if the tumor continues to be hard, it may be taken as a favorable or at least as a not unfavorable circumstance, since it is evidence that sufficient blood enters the sac to form a good strong clot, and also that circulation enough has been established to eliminate all fear of gangrene. But if, instead of remaining slight, the pulsation increases, more especially if its appearance has been later —from five to ten days or more after the operation—if the tumor again becomes softer, ceases to decrease, or perhaps even increases, however slightly, the deligation for and by itself has probably failed, and some additional measures will most likely be required. Pulsation returning some months after deligation, when the tumor has been some time hard and has sensibly decreased, indicates, as a very general rule, the occurrence of a fresh aneurism in the diseased part of the artery which lies near the original sac.

(3) When the branches of the tied artery, instead of being elastic and dilatable, are *rigid* from disease, or are unduly compressed by the tumor itself, by the diffused blood of a ruptured aneurism, or by improper circular constriction, *gangrene of the limb below the seat of deligation* is likely to ensue. The same event may follow undue exposure of the part to cold, or indeed any too potent application of warmth to an extremity rendered cold by the operation. Therefore it is more likely to occur in old than in young patients, in the lower than in the upper extremity. The higher the operation, the more imminent is this danger; for instance, unless in a subject advanced in years, or in one whose superficial arteries may be felt hard and rough from calcareous or atheromatous deposit, we may tie the superficial femoral with merely a remote chance of gangrene; but if the common femoral, the external iliac, or *a fortiori* the common iliac, be tied, sphacelus may more reasonably be dreaded. It is not a danger confined to deligation: I have known it to follow indirect,[1] and more especially direct pressure.[2] In some instances, and this may be inferred when the gangrene is unusually moist, it is owing less to arterial causes than to obstruction of the veins, either by pressure of the tumor itself, or by interference with or inflammation of the vein at the seat of operation.

The most usual time for the commencement of gangrene is between the third and fifth, or even up to the tenth day. Late sphacelus, for it may, as

[1] For instance, in Mr. Holmes's case of ilio-femoral aneurism mentioned on page 13 of my monograph on Aneurism (1880), but not as far as I know published elsewhere.

[2] Gangrene may result, in cases not subjected to operation, from the mere pressure of a large aneurism; hence if artificial compression in the situation of the tumor be added, the risk of such an event is by so much increased.

a rarity, occur even in the third or fourth week,[1] probably is due to phlebitis at the seat of ligature.

The prodromata of gangrene are increasing numbness, and a sense of weight and helplessness in the limb, followed by anæsthesia of certain parts—as the instep or back of the toes—while its further progress is marked by the appearance of a dusky-red or purplish spot, usually on or about the instep or back of the hand, while the toes or fingers become white. Then vesications form, with some œdema, which is especially well marked if the gangrene arises from venous causes. Afterwards the affected and previously red skin blackens, cracks, and gives exit to some blood-stained serum.

*Inflammation*, *suppuration*, or *sloughing of the sac* may occur after the Hunterian ligature, sometimes even a long time after. Their pathology and symptoms have already been detailed (p. 407); their numerical frequency for different vessels will be discussed in the next part of this article. The separation of an insoluble ligature is always a subject of anxiety. The question whether the ends of the severed artery have been sufficiently sealed to resist the force of the circulation, must always be present. This closure of the vessel is produced in part by retraction and folding in of the inner and middle coats divided by the ligature; in part by the adhesion of clot, above and below, to the wall of the vessel. Evidently a short clot, only a few lines long, offers less security than one of considerable length; hence the axiom, much insisted on when ligatures were always of insoluble material, never, unless absolutely obliged, to tie a vessel in close proximity to any considerable offset. To place, namely, a silk or other insoluble ligature on the superficial femoral, immediately below the origin of the deep branch, is to court secondary hemorrhage, by leaving between that offshoot and the ligature too short a space for the firm adhesion of the upper clot.[2] The surgeon should know for each vessel the average time at which the ligature "comes away." From the common carotid, subclavian (third part), and external iliac, it drops in from 21 to 30 days; from the superficial femoral, in from 11 to 20 days; from the brachial, in from 8 to 14 days, according to the part tied. As the threads hanging out of the wound keep up suppuration and prevent healing, it is desirable to get them away as speedily as is compatible with safety; but they never must be pulled off so as to sever the vessels by force. The rule of practice is, when the periods above specified have passed, to make gentle traction, and, if the cord do not follow at once, to desist. If after a considerably longer interval the ligature is still retained, a rather stronger pull may be given, since it happens occasionally that, even though the vessel be ulcerated through, the noose of the ligature, hitching in the opening in the sheath, or on some neighboring fascia, is retained. In a few cases threads have from this, or from some other unexplained cause, kept their hold even for months.

Temporary Ligature.—The dangers and troubles of a wound are aggravated by the presence of a foreign body twisted around the vessel. The not infrequent mishap of secondary hemorrhage, and the constant fear of such an event as long as the ligature remained, were defects that became only too evident as soon as Hunter's successes caused deligation to be a common operation. Dr. Jones, in his strictures on the action of the ligature, thought that

[1] Dr. Hargrave published a case (Dublin Medical Journal, March, 1865) of gangrene commencing on the thirty-first day.

[2] This example is chosen as the simplest. Many localities might be named, as the upper half-inch of the external iliac, the upper part of the common femoral, just below the epigastric and deep circumflex ilii, the lower end of the right common carotid, the first part of the subclavian, etc. It is to be noted that some recent experimentalists have thrown doubt on the value of the occluding thrombus, but, as we shall see, on insufficient or misinterpreted evidence.

he saw a way of eliminating these troubles altogether. To him belongs the first idea of the temporary ligature, all subsequent inventions being merely various mechanisms for carrying out his object. He found that when a ligature, or three or four ligatures, were tightly tied round an artery and immediately removed, circulation in the vessel was not restored. From the third to the fifth day, in this series of experiments,[1] the animal was killed (in one instance on the nineteenth day), and all the vessels thus treated were found closed by a firm block of "coagulable lymph," which glued together the wounded inner and middle coats; while outside the vessels a ring of like substance supported and no doubt helped to occlude them. Dr. Jones seems to have possessed no opportunities of testing these results on the human subject, but he infers from analogy that the same consequences would follow like momentary applications of the ligature to the vessels of man, and that the method might be used in certain diseases—notably in aneurism.

Since this time (1805) temporary ligatures have been fitfully used, and many different modes of employing them invented. Travers[2] tied knots of a description easily loosened, and left the ligatures longer than Dr. Jones had suggested.[3] A few cases thus treated ended successfully, but failure was far too frequent. Scarpa[4] next took up the cause, and showed experimentally that the ligature should remain from three to four days. After this period, an interval occurs, and we then come to temporary ligatures fastened and loosened by some instrument, this being generally a tube, either single and simple, or divided by a partition like a double-barrelled gun, the loop of the ligature projecting through one extremity, and its ends through the other. Other mechanisms are of the nature of forceps, held closed by spring or screw. The names of L'Estrange,[5] Wolfe,[6] Porter,[7] Bruns,[8] Nunneley,[9] Dix,[10] Billroth,[11] Bickersteth,[12] and many others, are connected with this form of temporary ligature, or its modification, "filo-pressure." Many of the instruments are both simple and ingenious; the mode of use is to lay the artery bare, pass the thread or wire round it, slide the tube over this, and secure it with sufficient pressure, leaving a means of easy removal. The names of other instruments, such as the artery compressor and canula forceps, sufficiently indicate their nature.

Dr. Fleet Speir's[13] method, and his instrument, or "artery compressor," are somewhat different, being rather an imitation of torsion than of deligation; they apply to vessels in continuity that rough handling—that, in the French sense, "insult to the inner tunics"—which gives to torsion of severed vessels its hæmostatic quality. His instrument is a tube, of size corresponding to the vessel under treatment, and carrying a sliding arm; one end of this piston-like arm carries a hook, the other a screw and nut. When the artery is bared, the hook is passed under it, and then the screw is turned until the hook and the vessel are drawn into the tube; the pressure thus inflicted ruptures the inner coats rudely enough to make them curl up and retreat within the outer tunic.

[1] Op. cit., chap. iii.
[2] Med.-Chir. Trans., vol. iv. p. 631.
[3] In a deligation of the brachial he had good success (50 hours); in one of the superficial femoral, failure (27 hours). (Med.-Chir. Trans., vol. ix. p. 405.) Roberts cured a popliteal aneurism by leaving the ligature only 24 hours.
[4] Memoria e lettere sulla legatura temporaria delle principali arterie degli arti, etc. 1825.
[5] Dublin Medical Press, 1865.
[6] Canula Forceps, British Med. Journal, vol. ii. 1867.
[7] Artery Compressor, Dublin Medical Journal, Nov. 2, 1867.
[8] Zeitschrift der Chirurgie, Bd. v. S. 317.
[9] British Medical Journal, vol. i. 1868.
[10] Ibid., vol. ii. 1875.
[11] Chirurgische Briefe aus dem Kriegslazarethen, 1871.
[12] Medico-Chirurg. Trans., vol. lvi. p. 129.
[13] New York Medical Record, April, 1871; March, 1872; February, 1873.

The temporary ligature, producing division of the inner tunics, followed by the formation of inflammatory adhesions, certainly possesses the power of occluding the arteries of animals, apparently in every experiment, even though the current is seen to persist immediately after the operation. The theory, as advanced by Dr. Jones, and afterwards supported by Porta,[1] Bruns,[2] and others, would be, if the arteries of man and of animals acted in like manner, indisputable, but this is far from being the case, as Hunter and Home found out;[3] and we must be cautious in drawing conclusions from these undoubtedly valuable experiments. The temporary ligature has, in a certain number of cases, succeeded, but it has more often failed, either by again permitting free flow of blood, by permitting the formation of an aneurism at the site of operation, or by giving rise to secondary hemorrhage.[4] The failures are in too large a proportion, the method is unreliable. The instrument of Fleet Speir is the best; the difference between his inner vascular wound and that left by a cord or wire, is similar to the difference between the wounds of arteries torn or cut asunder. Even the carotid has by this device been successfully occluded,[5] yet the plan cannot be considered entirely secure; and it would certainly appear that one or other of the modes of ligation about to be described must fulfil all the conditions of eliminating the dangers of foreign bodies—allowing healing by the first intention and, at the same time, affording greater security against reopening of the arterial channel by leaving, at all events for a considerable time, a circular constriction upon the vessel.

*Soluble Ligatures.*—It has been said that Sir Astley Cooper experimented with catgut ligatures with the hope that they might become absorbed or incorporated in the tissues: this hope was not fulfilled, and the matter was over-hastily abandoned; but many years after, Porta[6] made a great number of experiments with various substances—catgut, silk, hemp, horsehair, etc. In every case he cut the ligatures short and sewed up the wound, killing the animals afterwards at various periods, from four days to forty months. Of 290 ligatures, 64 were entirely absorbed in this order:—

| | | | | |
|---|---|---|---|---|
| 120 silk | . | 19 absorbed | . . | 15.8 per cent. |
| 80 catgut | . | 33 " | . . | 41.25 " |
| 50 flax | . | 10 " | . . | 20. " |
| 40 horsehair | | 2 " | . . | 5. " |

The table shows the great capability which dried fibrous animal structures possess of becoming absorbed by or incorporated in the tissues.

Professor Lister, in the pursuit of his aim, the avoidance of putrescent action in wounds, found that by treating catgut after a similar manner to that in which he treated wounded surfaces, viz., by the use of carbolic acid, he could, with the more certainty, cause it to be absorbed. He, therefore, introduced the carbolized catgut ligature.[7] The material which, on the strength of an experiment on a calf, he first recommended, was thus prepared by him: Take 1 part of pure crystallized carbolic acid, with only just enough water to keep it fluid. Mix this thoroughly by shaking it with 5 parts of olive oil. When the admixture is complete, steep in it the strands of catgut. This

[1] Delle alterazzione patologiche delle arterie per la ligatura e la torsione. Milano, 1845.

[2] Loc. cit.

[3] These distinguished men dissected off all the tunics of arteries in dogs, until the merest film, through which the blood could be seen flowing, was left. In three and six weeks, respectively, repair was complete, without either dilatation or contraction of the vessel. (Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge, 1793.)

[4] There are many such cases scattered in medical journals. Sands (Philadelphia Medical Times, Nov. 1874), gives four of this last description.

[5] Bell's case (Medical Record, Aug. 1, 1871), and Fleet Speir's own case of double distal ligature.

[6] Op. cit.

[7] Notes on the Ligature of Arteries on the Antiseptic System, 1869.

steeping must go on for at least two months, and is better continued for eight. The effect of this treatment upon the catgut is to render it much more soluble in the tissues; it has been used very extensively for sutures and for ligatures of vessels, both severed and in continuity.

Probably the next generation, or the younger members of this generation of surgeons, will be better able than we are at the present moment to assign its exact value to antiseptic surgery, its high wrought claims, and its evident exaggerations.[1] For myself, I conceive that by its aid we may perform certain operations, among them deligations of large and deep arteries, with greater certainty of obtaining union—if not by first intention, at least without suppuration—and this is undoubtedly a very important advantage. Probably the cumbersome and troublesome appliances, the spray, etc., will be very shortly superseded.

Among the various constituents of the antiseptic system, that which chiefly concerns us here is the use of a ligature which, whether it be organized or simply absorbed, does not act within the tissues as a foreign body, but allows the wound to heal, and is not seen any more, if, as doubtless occurs in a large number of cases, all goes on as it should do.

But the results of many cases have produced a certain distrust of this ligature—a distrust which is shared by the majority of operating surgeons, but which was probably first expressed in public by the late Mr. Callender,[2] and which has been augmented by the reports from time to time of the occurrence of secondary hemorrhage,[3] of the formation of a fresh aneurism at the place of deligation,[4] and of a rapid return of pulsation in, and persistence of, the aneurism;[5] while my personal want of confidence has been enhanced by the remarkably rapid occurrence of bleeding after tying a common carotid very low down, and by my finding the vessel cut almost completely through. It is not, of course, for a moment to be imagined that carbolized catgut always or generally leads the operator into such troubles; indeed, for tying severed vessels, this material, being a convenient cord ready to hand, will probably continue in use, since it closes the divided mouth of the vessel, and keeps it occluded sufficiently long to fulfil its object in these conditions; but its failures, when used on vessels in continuity, are only too frequent, apparently arising from the fact that its behavior on the tissues is uncertain. Thus a series of careful experiments by M. Arnaud[6] gives these results:—

*Carotid or femoral arteries of dogs tied fourteen times.*

| | | |
|---|---|---|
| Catgut disappeared | once | in 4 days. |
| " " | twice | in 7 days. |
| " " | once | in 9 days. |
| Catgut distinctly visible | once | in 4 days. |
| " " | once | in 9 days. |
| " " | once | in 11 days. |
| Catgut visible, but softened and infiltrated | once | in 16 days. |

[1] It must, however, never be overlooked that, just previous to the birth of antisepticism, many British hospitals, metropolitan and provincial, were much infested by pyæmia and other diseases originating in blood-poisoning, so much so that eight years ago a well-known surgeon wrote that what would be best for some of these institutions would be a free use of the pickaxe. (Erichsen, British Medical Journal, January and February, 1874.) The state of certain Continental hospitals has been raised by antiseptic surgery from a very lethal to a favorable one.

[2] Transactions of the Clinical Society, vol. xi. p. 108.

[3] T. Bryant, Trans. Clinical Soc., vol. xi. p. 1; Humphry, British Medical Journal, Sept. 14, 1874; Woods, Lancet, Aug. 28, 1875.

[4] T. Smith, Trans. Clinical Society, vol. xi. p. 51; Heath, Ibid., vol. xi. p. 40, and others.

[5] Barwell, Lancet.

[6] Contributions a l'étude de la ligature dans le traitement des anévrismes. Paris, 1880.

Thus we have such a range of periods within which the carbolized catgut may disappear or remain, that any surgeon who applies such a ligature, must feel a sad uncertainty as to what will happen.

Mr. Lister himself evidently feels that catgut prepared in the way he first recommended has failed to furnish a ligature suitable for tying arteries in continuity, since he has more recently instituted a series of experiments for the purpose of rendering the action of catgut in the tissues more equable and reliable by steeping them in chromic acid;[1] a mode of preparation, indeed, which Dr. Macewen, of Glasgow, had previously employed. But in a case of deligation of the external iliac artery, for which Mr. Lister had supplied the operator (Mr. Pemberton) with a length of chromicized catgut, the ligature came away four months after the operation in an abscess. A piece which the same gentleman supplied to Mr. Bellamy was used for tying the superficial femoral: the wound healed, save a space of about half an inch—a fissure, rather than a sinus—which led straight through the tissues to the ligatured artery. The man left the hospital after three months with this fissure still open.

In the mean time, the general dissatisfaction with catgut as a ligature in continuity caused many surgeons, myself among the number, to make experiments and trials with certain other animal substances, the result being that three materials may now be regarded as probably the best for tying vessels in aneurism. The suspensory tendon of the kangaroo's tail was proposed and used by Dr. Girdlestone, of Melbourne, in 1878.[2] A Japanese surgeon, Dr. Ishigouro, recommended tendons of the whale, which are strongly commended, also, by Benhenna and Baely;[3] while I chose the plan of surrounding the vessel to be tied with its own, that is, with arterial tissue. It does not probably much matter whence the animal tissue employed may come, provided that it be of the fibrous variety, be strong enough to bear a strong pull, be of a consistence that will retain a slight knot, and more especially be *fresh*.[4] It appeared to me, in studying all the modes of failure of catgut, and experimenting on different samples which I myself had prepared, that the extreme variability depended not on different methods or periods of carbolization, but on certain conditions of its first manufacture, which of necessity involved a certain, or rather an uncertain, amount of putrefaction, so as to allow the outer parts (peritoneum, etc.) to be scraped off with the back of a knife, while the same implement and action squeezed the mucous coat out of the tube under the form of dirt.

Another consideration weighed with me very strongly. I was aiming more especially at a ligature wherewith large vessels near the heart could be safely tied, more especially the innominate and subclavian, the deligation of which, when the patients have sufficiently survived, has always been followed by secondary hemorrhage. It seemed to me that if we could keep a vessel shut up for a sufficient length of time with a ligature that need not ulcerate through the artery, we might (the result of proximal pressure shows it to be possible) cure an aneurism without division of the two inner arterial coats. In other words, it seemed to me that the doctrine of Dr. Jones required revision. Now I found by experiments that round ligatures could not reliably be used, so as to leave those coats entire, but that flat ones, unless

[1] President's Address before the Clinical Society.

[2] First introduced into Europe by the late Mr. Callender. Clinical Society's Transactions, vol. xi. p. 703.

[3] Weekblatt van het Nederländische Tidschrjft voor Geneesk, No. 37, 1878.

[4] By this term I mean not used immediately on removal from the animal's body, but so prepared and stored that not the slightest taint of putrefaction, no beginning of decomposition, may have occurred.

jerked, or otherwise improperly handled, would always do so. Hence, after many trials and experiments, I hit on the notion of using the strong middle coat of the ox's aorta, and devised the following method of manufacture:—

Procure from a butcher the aorta of an ox (not split up, as is usual, but entire); see that it comes straight from the slaughter-house, and has not been kept; if it can be made into ligatures at once, it is better; if not, place it till opportunity offers in a three per cent. solution of carbolic acid. Strip off the outer coat.[1] The middle and inner coats are then to be cut with a pair of scissors spirally round and round, so as to make the whole into a tape-like cord.[2]

But in this state the material is too elastic to bear a reliable knot, and it disappears too rapidly, or at least does so in quadrupeds. Both these qualities are eliminated by suspending it and hanging upon it a weight of from one-half to two lbs., such as will stretch it half its own length; two feet of the unstretched should become three of the stretched ribbon. This should be done in an atmosphere warm enough and dry enough to dessicate the ribbon in about five hours, after which, should any irregularities remain, they may be scraped off with a sharp penknife. The material, as it dries, becomes translucent and horny; like vellum, it will keep any length of time rolled up in a coil, but must not be sharply bent while thus dry. I store it in antiseptic gauze under a glass shade.[3] About seventy minutes before use, it is to be steeped in a three per cent. solution of carbolic acid, when it becomes perfectly flexible. It also recovers a little of its elasticity, but not an inconvenient amount; indeed, the knot is probably on this account the more secure, because, in tightening, the material by stretching becomes thinner, and, on relaxing, enlarges again, the enlarged part outside the tie acting as a sort of strut against the knot, which thus as it were clamps itself. For passing it, an aneurism needle is required whose eye is slit a little longer than usual.

The cases in which this ligature has been used are not as yet many, but they have all been such as to show the reliability of the material and the soundness of the views above taught; they are:—

One left carotid.
Four right carotids } double distal operations.
Four right subclavians }
One right subclavian alone.
Two external iliacs (one perhaps was common iliac).
Five superficial femorals.
One popliteal.
One brachial.

In none of these sixteen cases has the ligature given any trouble, being never seen again; all did well as far as the deligation was concerned. Two of the cases should be especially noted. In a deligation of the femoral (by Mr. Bellamy) as the ligature was drawn tight, a little bleeding occurred a short distance above; probably a little branch running into the muscle was torn. At my request the operator passed two more ligatures of the same material

[1] At the upper part this tunic is from one-fourth to one-third of an inch thick, loose and almost spongy; lower down it is thinner and firmer. Care must be taken where the intercostals are given off not to tear the middle coat.

[2] After a very little practice it becomes easy to keep the ribbon equally broad throughout, or slightly tapering from the upper and thicker to the lower and thinner part; also so to manage the little openings for the small branches, that they do not interfere. I exhibited, at the International Congress (Parke's Museum), a piece of this ligature 36 feet in length.

[3] For further details, see the author's monogragh, already quoted; also various papers in Med.-Chir. Trans., 1878, 1879, 1880, 1881.

above and below, there being thus three bands in the space of an inch or a little more; this was a severe test, yet the wound healed by the first intention, and nothing has since been heard of the ligatures. The brachial artery of a child, aged nine, was tied on the 19th of June, 1881, by my house surgeon, Mr. Taylor, for consecutive traumatic aneurism of the ulnar artery near the wrist. The ligature used was the stoutest carbolized catgut prepared. Exactly a week after, hemorrhage occurred both at the operative wound and from the aneurism. I examined the former, and found the knot of the ligature lying upon the vessel, but quite loose, the loop having entirely disappeared. The vessel was divided through about one-third of its circumference. I re-ligatured with ox aorta ribbon above and below. No bleeding occurred afterwards, and though the wounds had to heal by granulation and suppuration, and though the operation was not antiseptic, nothing was afterwards seen of the ligatures, and the child did perfectly well.[1]

At present it is not quite possible to say what ultimately becomes of these ligatures made from animal fibres. Mr. Lister's first idea was that they became organized,[2] but he has since energetically repudiated this view; probably his denial is correct with regard to catgut, because that material is to a certain extent putrefied, but fresh substances— kangaroo or whale tendon, and vascular coats—do I believe become organized and become part of the body into which they are inserted, for vessels form within them.[3]

The occurrence most dreaded after deligation of an artery is hemorrhage at the site of ligature. A non-absorbable cord which must divide the artery in order to come away, evidently exposes the patient to this risk. An organizable or absorbable material, if it properly fulfil its object, ought to exempt from this danger, but records which will be presently given show that this is by no means the case with catgut, nor do I think that any form of ligature which severs the middle coat of the vessel can be entirely safe.

The *treatment of secondary hemorrhage at the place of deligation* is not by any means always successful; sometimes a simple pad and bandage suffice to arrest the bleeding, but often the choice of a suitable mode of treatment presents great difficulties. This variability depends on the proximity of the vessel to the heart, on its calibre, on the size of the rent in it, on the number and volume of branches given off immediately above and below the point of ligation, and on the freedom of their inosculation, whereon in great measure the length and steadfastness of the thrombic clot depends. The freedom of inosculation is an important factor, since the bleeding not infrequently comes from the part of the vessel beyond the ligature.[4]

The treatment must in part depend upon the situation of the tied vessel, in part on the amount and rate of bleeding. It is plain that if an artery within or close to the trunk be the seat of hemorrhage, our resources are more

[1] Lancet, July 30, 1881. [2] Ligature of Arteries on the Antiseptic System.

[3] Space will not permit me to follow here the different views held regarding this organization, this coming to life again, of tissues taken from a dead animal and translated into a living body. Mr. Dent (Med.-Chir. Trans., vol. lxiv. p. 231, and Lancet, March 26, 1881) has shown very clearly that the kangaroo tendon becomes vascularized, and hence we may suppose that it is nourished; and I have had the opportunity of showing several remains of ox aorta ligature at different dates, the oldest, at fifteen months, being inseparably mixed with the surrounding tissues. (Med.-Chir. Trans., vol. lxiv. p. 225, and Lancet, March 12, 1881.) The contention as to whether the actual elements of the materials remain or are replaced by new ones, appears to me unimportant. The latter is the fate in the animal economy of all used tissues, yet the whole organ, though interstitially changed, remains the same. A muscle for instance, after much use, even though a great part of its sarcous elements may have become effete and have been replaced, is substantially the same and not a new muscle. I have no doubt that many fibre-cells of the organic ligatures are changed for others; but as a whole the material must be considered as persistent. But, as my cases show, these ligatures ultimately diminish in bulk like any other part of the body when their function is fulfilled.

[4] This is nearly always the condition of secondary hemorrhage after tying the subclavian.

limited than if the bleeding vessel be in a limb at some distance from the body. In the latter case, if the hemorrhage be not a formidable and rapid gush, we may estimate approximately the size of the arterial wound by watching the nature and amount of the flow. If this be brisk but not violent, we may elect either to apply pressure by pad and bandage, or to cut down on the vessel and tie it again both above and below. If the former course be chosen, the thumb should be pressed firmly just above, and afterwards just below, the wound, and at whichever point pressure most effectually checks the bleeding, there should the pad be thickest. Having then made a graduated compress arranged in this manner, it should be held by an assistant steadily over the seat of hemorrhage while the bandage is firmly applied from the extremity up. A few minutes' attention will show whether the bleeding is checked. Even if successful, further precautions should be taken. A tourniquet, or better, if dealing with the lower limb, one of the compressors used for the cure of aneurism, should be applied to the artery above, with sufficient force to mitigate the force of the circulation, yet with such moderation as to render the pressure bearable for some hours. Some trustworthy person must be left in charge, who is frequently to examine the dressings, and who, on any appearance of blood, must screw the instrument tighter and send for the surgeon.

Unless this recurrent bleeding be very slight, it is generally better not to go on with pressure, but if this be continued, another method of application should be used. The wound may be opened, thoroughly cleansed from all clots, and dried, while, if possible, an assistant compresses the vessel above; then bits of perfectly dry sponge or yarn, not bigger than horse-beans, may be stuffed well home into the bottom of the wound, piece upon piece, until the whole is quite full,[1] when, by applying a bandage over the whole, very firm pressure can be made. Another plan is to fill the wound with very small shot, pressed well in till the parts around are prominent. The disadvantages of these methods are the proneness to blood poisoning if the foreign bodies have to remain long, and the danger of recurrent hemorrhage if they are removed quickly. They act by their direct pressure, and by causing the blood to coagulate in their interstices and around the wound in the vessel. I have never had occasion to use shot in this way, and, should the occasion arise, I should prefer a finer, innocuous powder, such as that of oxide of zinc, or of bismuth, through which blood could hardly percolate, and with which some preservative might be mixed.

Any or all of these methods may fail, or it may from the first be deemed better to tie the vessel above and below. The choice must chiefly be guided by the sort and rapidity of the hemorrhage: a severe bleeding is rarely arrested by mere pressure. The length of time since the operation must also have its influence on our selection: if this be only ten days, I think it far better to ligature at once, since, unless it be a very deep one, the vessel is very generally easily found, especially if a large part of the wound be still unhealed. The artery above should be commanded by an assistant's thumb, by a tourniquet, or by an Esmarch cord.[2] If an undissolved ligature hang out of the wound, it affords a sure guide to the vessel; but in truth a guide is hardly needed, because the original wound only reached to the artery, and if with the finger we clear away the clots and the still soft, newly formed tissues, we must find the vessel at the bottom;[3] but it is not very easy to discover the bleeding

[1] In one case, I believed that a certain advantage was obtained by first dropping into the wound three minims of extract of ergot with seven of glycerine.

[2] If there be time to apply the flat band and cord, much is gained by permitting a good view of the parts.

[3] At least this has always been the case when I have had to perform this operation.

point among sodden and swollen parts. A few drops of blood allowed to flow out, may assist the search; or the vessel may be dissected some way above and below the place where it was originally tied, and fresh ligatures be placed a good distance away, above and below. After that, it is well to pass under the artery a blunt hook and carry it down from one ligature to the other to make sure that no large branch springs between the two, for if such a branch be left, bleeding will be apt to recur from the collateral flow; should such a branch be found, it must also be tied. Some surgeons would tie with hemp or perhaps catgut, and divide the vessel between the two knots.[1]

Deligation of the artery, *above and below the point of hemorrhage*, sometimes succeeds,[2] but often fails, the failures being chiefly due to disease of the vessel. Generally the same condition which gave rise to the first hemorrhage causes the second operation also to fail; but sometimes, I believe, suppuration in the wound, by softening the arterial tunics, renders them unfit to bear a new ligature—more especially one that divides the vessel's coats.

Another method may be used if the bleeding come from the distal end of an artery divided, or partially divided, by the ulceration caused by an insoluble ligature. In such a case it is evident that some large collateral branch brings blood from a vessel on the proximal side, along a branch opening into the main channel on the distal side of the wound. This branch may be accessible to a ligature. In this way Smyth, of New Orleans, saved a patient for whom he had tied the innominate, and who had had repeated attacks of secondary bleeding from the distal portion of the vessel. On the fifty-fourth day the vertebral, which brought blood from the brain, was tied; the hemorrhage was arrested, and the man recovered. This method is especially adapted to the branches of the subclavian, but may, in case of urgency, be tried elsewhere, though with less hope of success.

*Deligation of the vessel higher up*, or of the *main branch* from which it springs, is a device which is not often successful—more so, however, in the upper than in the lower limb, for in the latter such an operation is peculiarly liable to be followed by gangrene, an event which renders the result of the *ultima ratio* doubtful. Hence hemorrhage—after tying, for instance, the superficial femoral—should only be treated by deligation of the common trunk in a person not advanced in years, having fairly sound arteries, and whose limb has not suffered from the first operation.[3] In dealing with the upper limb, gangrene need hardly be feared, but when the vessel above has been bared, strict search should be made for any such irregularity as a high division. The original ligature may have constricted the aneurismal vessel, and yet, when the side-channels have become enlarged, an aberrant branch from the other portion of the artery may carry blood into the aneurismal portion close to the place at which it was tied. In certain cases all these devices, one after the other, fail, either from some inherent defect of the vascular system, analogous to that which produces hæmophilia, or because the arteries of the part have been damaged by previous treatment.

Case XV.—As an instance of such ill results I may quote a case which occurred in the practice of Professor Agnew: A popliteal aneurism was treated successively by the Esmarch bandage, pressure, flexion, and then by ligature of the superficial femoral;

[1] I do not recommend such a division if the flat ligature be used, as I do not feel confident, since it does not bury itself in the arterial tissues, that it holds upon a divided vessel; it might—I have never seen such an occurrence—but it might be pushed off by the force of the current, or the retracting vessel might withdraw itself from the noose.

[2] See Humphry's case (British Medical Journal, 1876, vol. x. p. 591) and my own case (Lancet, August 3, 1881), referred to at p. 445.

[3] This observation cannot hold in regard to the external and common iliac, because in cases of hemorrhage from these vessels we cannot amputate, and to tie them may be our only resource.

on the ninth day there was hemorrhage from the wound, and the vessel was tied above and below; in a week, bleeding recurred, and was found to come from the profunda; this vessel was ligatured with the same result; the common femoral, the external iliac, and the common iliac, were then tied, one after the other, each time for reiterated bleeding. Then an unnamed, enlarged branch, overlying the common iliac, and afterwards the obturator and epigastric arteries, were tied. The man succumbed to repeated hemorrhages.[1]

Hence it is prudent, if, after tying in the wound has failed, deligation above be employed, to avoid going so high as to deprive the patient of the last life-saving chance—amputation. If the third deligation high up in the limb fail, it appears useless to go higher—into the trunk, for instance. If that be done, life literally hangs on a single thread.

To sum up, *amputation* is, when situation permits, sometimes the wisest and the safest course, especially in the lower limb; as when, after the primary deligation, the parts below have been long in recovering circulation, or have barely recovered it at all; when, in the course of that procedure, the vessel has been found diseased; when the deligation, though producing hemorrhage, has not cured the aneurism; or when, after apparent cure, signs of inflammation or suppuration of the sac have set in.

When deligation at the wound has proved futile, and the patient has lost much blood, tying further up is rarely useful. Still less when a higher ligature has failed should it be repeated; and most certainly not if the third ligature must be in a place that would preclude amputation.

Amputation for secondary hemorrhage is rarely necessary in the upper limb, since the vessel—or, if necessary, more than one vessel—may be tied with little risk of gangrene. In the lower limb, the ligature placed on the vessel above is frequently followed by gangrene. Since that result would necessitate amputation, the surgeon may resort *ab initio* to this operation with the less compunction after all reasonable means, that is, all that do not evoke more dangerous complications, have been tried.

*Suppuration of the aneurismal sac* after a lengthy interval—about or over two months after treatment by pressure or ligature—is not usually accompanied or followed by hemorrhage. It is very rarely thus complicated if, among the local symptoms, pulsation be not included. When, on the contrary, the phenomena about to be described present themselves within two months of such treatment, which may have been apparently quite successful, bleeding generally ensues, especially if pulsation has returned.

The symptoms are very similar to those of an ordinary acute abscess. The patient, up to this time progressing favorably, experiences *malaise*, perhaps has one or more rigors, and is restless and feverish, with a temperature of from 100° to 102° Fahrenheit, or even higher. The tumor, which was getting smaller at first, ceases to decrease, and after a little while becomes markedly larger. It is painful, often intensely so, and usually hot; in a little time it fluctuates, or at least the surrounding tissues do so, and the skin becomes of a dusky red. The addition of pulsation is a grave complication. If the swelling burst or be incised, discolored pus, often fetid, and after a time coffee-colored or plum-colored, is evacuated; deep purple and grayish detritus follows. Sometimes immediately after, a few drops, or perhaps a stream, of bright arterial blood issues from the wound; in other cases this flow is delayed for a few hours, or even for a few days; in some cases, especially in those in which the suppuration has been long delayed, hemorrhage may not occur at all, but it is to be dreaded as long as the wound discharges grumous matter, or has not become filled by healthy granulations.

[1] Philadelphia Medical Times, Nov. 10, 1877, p. 56.

It nearly always occurs immediately, if, while swelling, the tumor also pulsates pretty strongly.

The treatment, therefore, of a sac suppurating after deligation, is to seize a favorable but early moment for incision. It never should be allowed to burst, lest, in the absence of skilled assistance, the patient die of hemorrhage. Neither should opening the tumor be hurried, or performed without due preparation, and without having such appliances in readiness as may be necessary for further measures. A tourniquet should be applied loosely above the sac, before the incision is made; on no account should the abscess be kneaded or pressed, after it is opened, but it should be simply covered with a cold wet cloth; if no bleeding follow in fifteen or twenty minutes, the patient may be left to the care of some well-instructed nurse or assistant, who should be instructed to screw the tourniquet home on the first appearance of bleeding. After the first twenty-four hours, the danger of hemorrhage greatly diminishes, though as long as shreds of clot, purple or fleshy lumps, come away, absolute security is not attained. If a little bleeding follow the incision at once, or arise shortly afterwards, the finger should be gently introduced, and all the soft, broken-down matters which come away easily should be abstracted. A solution of carbolic acid, 5 per cent., mixed with an equal bulk of the liquor ferri perchloridi, may then be poured in, and after a few minutes the chasm left by the evacuated matters may be stuffed somewhat tightly with lint or tenax, while pressure is kept up by a bandage.

If from the first or at any subsequent time the bleeding be more severe, the best practice is to empty the sac in the manner described in speaking of "the old operation;" then, looking at the now naked wall, the surgeon must discover the source of hemorrhage. This may be the vessel above or below, or some side channel opening laterally into the sac, or, again, the blood may come away from innumerable orifices after the manner of general oozing.

In the last event some styptic, such as ice, the perchloride of iron, or the chloride of zinc, combined with direct pressure and the internal use of ergot—perhaps the actual cautery—may prove effectual. Proximal digital pressure should be tried while the wound is under watch, and if it check or greatly diminish the bleeding, may be used alone, or together with direct compression.

If a distinct bleeding orifice be perceptible, the vessel leading to it should be tied with one of the ligatures that do not divide the arterial coats. This operation is, if the opening belong to the main vessel, precisely like the "old operation" already described (p. 432); but if the bleeding spring from an enlarged collateral branch that runs into the sac from the depths of the limb, the procedure is even more difficult. It is presumed that the opening in the sac has been made wide enough to afford a good view, and therefore probably to give room for work. Into the bleeding orifice a probe must be passed, and around it, at a few lines' distance, an incision should be made with the scalpel deep enough to give a good hold to a pair of forceps, which now can seize the parts around the bleeding orifice and permit a ligature to be thrown around them. If the part be very deep, however, this is impossible; but a thread of silk or hemp may be armed with semicircular needles at both ends, and with a needle holder each may be passed in a different direction half around the orifice, at a sufficient depth to insure that the thread entirely surrounds it.

A second deligation nearer the sac may be attempted; especially if pressure so severe, or in such a situation, as to be insupportable for a sufficient length of time, be found to arrest the bleeding. If all fail, amputation is the only resource, and this should not be delayed until the patient is greatly

exhausted by loss of blood. As in secondary hemorrhage from the site of deligation, so in bleeding from a suppurating sac—more especially if in the lower limb—gangrene is very apt to follow the renewed application of ligatures.[1]

Most of the mortality from suppuration of the sac after ligature is due to hemorrhage. There are, however, other dangers, viz., exhaustion, hectic, and blood poisoning; these must be combated on those principles which are detailed in other portions of this work.

*Gangrene of the limb* after ligature does not materially differ from certain forms of gangrene from other causes, as for instance from embolism or from arterial disease, so that it will not require any separate description or recommendations for treatment in this place.

It has been said (p. 438) that occasionally, after the application of a ligature, *pulsation*, having for a time been annulled, may return; and several modes of recurrence, as immediate, early, and late, have been enumerated. Immediate, recurrent, or continuous pulsation is often due to anatomical abnormity,[2] which should at once be investigated; but if very slight, it may be the consequence of a previous attempt at cure by pressure, which has too greatly enlarged the collateral vessels. Early recurrence—that is to say in from twenty-four to forty-eight hours—is, as a rule, due to large collaterals, and, therefore, is more common at those places where normal inosculations are large. Unless the pulsation be considerable, its prognosis is favorable, but not if the aneurism beat as strongly, or nearly as strongly, as before the operation, and if it continue to increase.[3] Recurrence in about a fortnight offers a less favorable prospect. Secondary aneurism, that is, a new sac, arising close to the site of the former tumor (a somewhat rare event), either manifests itself shortly after the patient begins to move about, or some months afterwards. In all these circumstances, save when very slight pulsation occurs within forty-eight hours, a pad upon the aneurism, secured by a moderately tight bandage, should be employed; the extremity must be watched lest gangrene be produced. The limb may be raised, and if it be the lower one—especially if the aneurism be popliteal—flexion may be employed. Pressure (digital, in preference) may be applied above the place of deligation. Cold, applied by means of ice, has been recommended, but must be used with the greatest caution. If the ligature have given way, the vessel should be tied again with the ox aorta ligature, above and below the seat of primary deligation, or the vessel may be thus doubly retied with hemp, and divided where the first ligature was placed.

Indications for and against Deligation.—These may, in part, be gathered from the above account of its failures and its dangers. The circumstances which should deter from operation may be such as affect the system, or, at least, the circulatory system, generally, and such as belong to the particular vessel involved, and to the aneurism.[4]

*Heart disease*, namely, mitral or aortic incompetence, if well marked, would negative ligature, especially of a considerable vessel; slighter affections of the same sort would not do so. A very weak heart, believed to have thin

[1] Some writers have spoken with despair of tying vessels leading to a bleeding, suppurating sac. I believe that the newer forms of soluble ligature place this matter on an entirely different footing from that which it has hitherto occupied.

[2] That is to say in proximal, of course not in distal deligation.

[3] Some cases of recurrence from failure of the ligature are noted at p. 442.

[4] It is presupposed, in the ensuing paragraphs, unless stated to the contrary, that the aneurism is not in a condition very rapidly to destroy life, and that other measures have been either tried, or for some good reason rejected.

walls and to be fatty, as also lung congestion from valvular disease, would form strong objections to deligation—the latter condition, more especially, if a large artery about the neck were in question. General *atheroma*, or the same condition if well emphasized, even though confined to the aorta, would furnish a contra-indication, and again more particularly about the neck, or if so large an operation as tying the abdominal aorta or the common iliac were in question. *Aortic aneurism* should negative deligation for external aneurisms.

*Local disease of the artery* about to be tied, would certainly deter as long as one could hope that life was not immediately threatened by the progress of the disease. At the same time I must state my belief, borne out by experience, that a vessel, even though considerably atheromatous, may be successfully tied if a ligature that need not cut the arterial tunics be used, and if care be taken not to cut them. Probably, however, extensive calcification would not allow any ligature to be safely used at the degenerated parts.

*Conditions of the aneurism itself* which would negative the Hunterian deligation are described by some writers as very many. Rapid growth, thin walls, and forcible pulsation, do not, however, in my opinion, forbid deligation. It is true that suppuration and bursting of the sac may occur, especially if the tumor be surrounded by loose tissues, such as those of the axilla; but if these cases be left to themselves, rapid, if not sudden, death is inevitable, whereas after ligature the sac may not burst, and, if it do, hemorrhage will be less severe and more easily restrained, since the main channel is cut off. The patient, or his friends, should know, however, that the chances of failure are in such a case considerable. The artery should not, under these circumstances, be tied at a great distance; sometimes indeed, as in axillary aneurism, it cannot be so ligatured; hence the surgeon, before proposing the operation, should ascertain that the part of the vessel which he wishes to reach is not aneurismal, and that it is not covered by the sac springing from a place further on.

When the limb beyond the aneurism is œdematous, application of a ligature to the main artery is apt to be followed by gangrene. Whether or no the knowledge of this fact should preclude deligation, depends on many circumstances:—

If the aneurism be growing quickly, while its walls are becoming thinner, so that its ultimate rupture is a mere question of days, the ligature may be, and often is, the only chance of saving life; it is true that amputation may afterwards be necessary, and that the patient must then pass through another ordeal, more or less dangerous; but life may be saved.[1]

If the aneurism, which may have been increasing, have ceased, or nearly ceased, to grow, it will be well to investigate the cause of the œdema; it may arise simply from pressure on the vein, or it may be that form of subcutaneous and subfascial swelling which is only the first step of a widespread and rapid gangrene. The distinction between the two conditions is to be found in the state of the smaller veins, and in the temperature. A cold insensitive limb, white and bloodless, shows that want of passage through the artery is causing, as it were, death by starvation;[2] while, on the other hand, a more marked and deeper swelling, with a high red or lurid coloration,

[1] I would refer here to a case thus already mentioned, under the care of Mr. Holmes; the man had ilio-femoral aneurism; after pressure, gangrene of the leg supervened, but, nevertheless, that surgeon and all his colleagues thought it his duty to tie the external iliac; in this view, I, being present, agreed. After deligation with the ox aorta ligature, the aneurism became solid. I do not think that the gangrene increased much in extent; the limb was amputated a little above the knee; and the man is now alive and well.

[2] Occasionally parts, more rarely wide tracts, of such a limb are hyperæsthetic.

marked by a meshwork of large full veins, shows obstruction, not to the onward, but to the returning current.

Whether or no, in the former of the above states, the artery should be tied, must be decided by the condition of the aneurism: when that sort of gangrene sets in, very rapid, almost sudden solidification sometimes takes place. It is therefore wiser to temporize, unless the sac be getting thinner and larger.

In the second condition, it is also as a rule best to endeavor to reduce or diminish the swelling before resorting to the ligature.

In certain cases, much of this venous engorgement may be removed by adopting one or all of three measures: (1) Change of position, which by altering the place of the sac obviates the pressure; (2) Elevation of the limb; (3) Careful, not too firm bandaging, frequently renewed.

After a time, and whether or no these means have succeeded, the artery should be tied, partly because by that means the amount of blood passing to the over-filled limb is diminished, and partly because the aneurism will probably decrease and allow the vein to resume its function.

Allusion has already been made (p. 439) to the place of deligation in regard to branches given off from the main vessel. Had the principles of thirty years ago, viz., never to tie near a large branch, been rigidly adhered to, very few vessels of the body would have undergone deligation. But the extent of the internal clot, important as it is with ligatures that must come away, is perhaps less so with those that are left around the artery, and probably (for I must speak with a necessary lack of experience, which time alone can give) ligatures which remain on the vessel, and do not divide its inner coat, are secure against secondary hemorrhage, whether or no a thrombus form. If this view be correct, no part of a vessel accessible to ligation at all, can be unsuited for that sort of band. Nevertheless, when circumstances permit a choice, prudence would forbid deligation to be practised very near to some great branch.

## Aneurisms of the Lower Extremity.

The terminal vessels of the extremities are rarely aneurismal unless from direct wound,[1] and the vessel least uncommonly affected by this condition is found to be the dorsal artery of the foot, the disease occurring here, probably, as the result of pressure by an ill-fitting boot, or of sprain, and sometimes as a sequel of gunshot injury by a spent ball which has merely bruised the part. Less frequent are aneurisms in the sole of the foot, and behind the malleoli, more especially the outer.

Aneurism of the Dorsal Artery of the Foot.—This is a far more serious disease than the size of the vessel would seem to warrant; nor is its cure by any means easy. This is no doubt owing to the free communications which exist between the three vessels that nourish the extremity, so that the sac is probably in connection with more than one artery, and may lie, as some dissections have shown, partly between the bones.

The cases are not very common: I have been able to collect eighteen, four of which followed direct wounds, while three were ascribed to sprains, and four were classed as spontaneous; in the records of six no mention of casualty is made.[2] The tumor is usually situated over the scaphoid or internal cunei-

[1] I have excluded the erroneously named traumatic diffuse aneurism, but a few such cases are on record.

[2] Fourteen of these cases are cited by Delorme. (Gazette Hebdomadaire, No. 9, 1879). Of these the earlier ones are taken from very short and unsatisfactory notices. Two more are in the Zeitschrift der Chirurgie, Bd. xii. S. 477. One is in the Philadelphia Med. Times, March 21, 1874; one in the Brit. Med. Journal, Dec. 8, 1870.

form bone; the further forward its place, the more likely is it to be serious and difficult of management, as, when it lies at the root of the metatarsus, the branch communicating with the plantar arch is likely to be involved, and some part of the aneurism will then be interosseous. The size is usually about that of a hazel-nut; but it may reach that of a bantam's egg. The following table shows the result of treatment in the fourteen cases the management and fate of which have been ascertained. It will be seen that pressure succeeded, although with difficulty, twice, and failed seven times; in two of the unsuccessful cases, death was the direct result of the treatment. Ligature, either above, or both above and below, was practised seven times: three times after failure of pressure—in these cases a successful result followed—and four times primarily; in two of these, simple deligation was followed by opening the sac and amputation; in one, simple failure is recorded; in another, death followed. Coagulating injections were employed twice, and each time successfully. Opening the sac was practised four times, and the end in all but one case was death.

| Treatment. | | Result. | Cause of death or amputation. |
|---|---|---|---|
| Failure | Success. | | |
| Ligature above and below | . . . . . . | Death | Gangrene. |
| | Pressure severe | Cure | |
| Pressure indirect | Ligature above | Cure | |
| Pressure indirect | . . . . . . | Death | Gangrene and rupture of sac. |
| Ligature and opening sac | . . . . . . | Amputation | Gangrene and hemorrhage. |
| Pressure indirect prolonged | Ligature above | Cure | |
| Pressure indirect | Ligature peroneal[1] | Cure | |
| Pressure indirect | Coagulating injection | Cure | |
| Ligature above | . . . . . . | Failure[2] | |
| Esmarch. Pressure. Opening sac | . . . . . . | Death | Gangrene and hemorrhage. |
| | Pressure direct and indirect | Cure | |
| Pressure. Opening sac | . . . . . . | Death | Hemorrhage. |
| Esmarch. Several times galvano-puncture | Coagulating injection | Cure | |
| Ligature. Opening sac | . . . . . . | Amputation | Survived.[3] |

The inferences are, if we accept the teaching of so small an experience, clear: Not to open the sac, not merely on empirical, but also on anatomical grounds. To employ direct pressure, which at this part is very painful, tentatively only; and unless it bring marked amelioration, not to continue it very long. Indirect pressure at this part is exceedingly painful, nor is any form, save on the femoral, capable of controlling pulsation. I would suggest the use, with or without an anæsthetic, of the Esmarch bandage, applied in the erect posture that the sac may be full—the tumor being omitted from the coils of the bandage—followed, after an hour, by instrumental pressure with Signoroni's tourniquet on the femoral, alternating with digital pressure on the dorsal artery as it passes over the margin of the trochlea astragali. In case these fail, the choice lies between coagulating injections and the ligature. Now no part of the body could be better adapted for the use of a coagulating fluid than the dorsum of the foot—there being so little beyond the sac which could be injured by its action; nevertheless, the arteries beyond must first, if possible, be occluded, and the femoral above restrained—the sac should be

[1] In this case the surgeon cut down on the anterior tibial, but could not discover it, finding two veins (?) instead.
[2] Patient left hospital with tumor still pulsating.
[3] The sac did not apparently need to be opened.

well filled. The injection has been relatively more successful than the ligature; but some of the failures of the latter occurred at a time when the elements of safety in such operations were but ill understood. My personal predilection would be, after sufficient trial of pressure, to tie the artery above and below; if after a week pulsation continued, to use cautiously an injection of the weaker formula given on p. 413.

Should this fail, a further choice lies between an amputation (Chopart, Syme, or Pirogoff, according to the situation of the aneurism) and deligation of the posterior tibial. If after the anterior artery has been tied, the persistent pulsation can be commanded by pressure behind the inner malleolus, the latter course should be chosen. I am hardly prepared to advise ligature of the common femoral, and do not think that good would result from tying the superficial branch.

I am not aware of any instance of aneurism occurring at the *outer side of the foot*, nor of any case in which the *peroneal artery* has been tied for such a disease, except the curious instance embraced in the above table, in which some anatomical peculiarity appears to have been present.

Plantar Aneurism.—In the *sole*, when aneurism occurs, it involves the external plantar artery, and is usually situated over the cuboid bone, or sometimes at the base of the first metatarsal bone. Here again the presence of communicating branches causes some difficulty in treatment, which must be conducted on the same lines, *mutatis mutandis*, as that of aneurism of the dorsal artery.[1]

Aneurism of the Anterior Tibial.—The anterior tibial artery rarely becomes aneurismal. When it does so, the disease occurs usually over the flat surface of the tibia, just above the ankle-joint; or high up, just below where the artery perforates the interrosseous membrane. I do not know of this vessel being affected in the middle of the limb.

Both forms of the disease are generally curable by the Esmarch bandage, or by acute flexion of the knee. The high form is more amenable than the lower to indirect pressure on the femoral. I would recommend the trial of these three measures, in the order mentioned. The two latter should be at first only tentatively employed. If flexion do not either completely or very nearly arrest the pulsation, it should be discontinued. If after from 16 to 24 hours, pressure on the femoral, spread over three days, do not effect material improvement, it will, probably, fail even on longer application. These efforts should not be carried as far for the low as for the high variety, since tying the anterior tibial in the lower third of the leg is a very simple operation, which should also be very safe, but which is only efficacious when the aneurism lies low in the limb.

*Deligation of the Anterior Tibial Artery in its Lower Portion.*—This vessel might be marked out on the surface by a line running from the upper tibioperoneal articulation to a little inside the centre of the ankle-joint. It lies throughout its course in contact with the outer aspect of the anterior tibial muscle, and may best be exposed by making an incision through the superficies just outside the tendon of the same name. By pressing the edges of the cut aside, with either the finger or the handle of the knife, the deep fascia is sufficiently cleared to show the inclosed parts marking it with white lines.

[1] A case of this aneurism, cured in four days by pressure on the anterior and posterior tibial, and direct compression of the tumor, is quoted in the Boston Med. and Surg. Journal. Jan. 29, 1874.

On the outer side of that broad line, which the anatomist at once knows to be the anterior-tibial tendon, the fascia is to be slit up, exposing a little space between the above-named tendon and that of the extensor proprius pollicis; and in this space the artery is easily seen, with the nerve, unless the incision be unusually low, on the outer side. The artery is here surrounded by two companion veins and their cross-branches, which are bound to it by a thin, sheath-like fascia; and the operator may, if he will, separate these with the eye-end of a probe, or with an aneurism needle; but he will then probably break some of the communicating offsets, and I think it better, upon the whole, to include the companion veins in the ligature.

*Ligature of the anterior tibial artery above the lower third of the leg* must be very rarely required, and then for wound rather than for aneurism. The operation is performed in much the same way as that just described, but the vessel lies deeper, though in the same relative situation with regard to the muscle of like name. This operation is hardly practicable in the upper third of the leg, since the vessel pierces the interosseous membrane from $1\frac{1}{2}$ to 2 inches below the tibial tuberosity. The surgeon operating at some point in the middle third of the limb, feels the crest of the tibia, and, estimating the breadth of the anterior tibial muscle, makes a longitudinal incision at that distance from the bone, and, using his finger, clears the deep fascia. He now holds the wound open, and moves it from side to side until he recognizes the whitish-yellow line that marks the offset of the intermuscular septum between the anterior tibial and the extensor longus digitorum;[1] and here the fascia is to be split up. Generally the blade of the scalpel may now be laid aside, and the handle used to separate the muscles. In doing this, the operator must be careful to keep the instrument next to the anterior tibial muscle, and to turn the extensor proprius outwards with the common extensor of the toes. It may be that he will come to the region of the artery—may even see the nerve overlying it—and yet cannot encircle it by a ligature, because it lies in a separate compartment of the intermuscular septum; if so, a few cautious touches of the knife must open up this sheath till the nerve is bared, when, by drawing this outward, the artery with its encircling veins is exposed. Artery and veins may then be surrounded by the ligature, which is most readily passed, either with an eyed probe properly bent, or with an aneurism needle having a sharper curve than usual. There is no difficulty in the operation beyond the depth at which the vessel lies; and this, since no important part lies between the artery and the skin, should be no impediment to its performance. The secret of facility is to carefully avoid dividing, and going astray among, muscular fibres which should be left quite intact.[2]

ANEURISM OF THE POSTERIOR TIBIAL ARTERY.—This is less uncommon. I find in a period of ten years, four cases recorded.[3] [Dr. R. A. Kinloch has tabulated[4] twenty-two cases of spontaneous aneurism of the posterior tibial artery, including one of his own, with seven deaths and fifteen recoveries.] Spontaneous aneurism of this vessel occupies usually the upper half of the leg, attains a considerable size before it makes its presence known, and forms a considerable tumor, lying at the back of the leg, rather on its inner aspect,

[1] Unless the incision be quite in the lower part of the middle third, the extensor proprius pollicis will not have come to the front.

[2] The rarity of these cases may be inferred from the fact that I find in the last ten years but one case recorded. (Medical Times and Gazette, April 11, 1874.) Mr. Erichsen failed to cure this case by digital and instrumental pressure, combined with ergotin injections. The man passed out of observation, declining further treatment.

[3] British Medical Journal, January 27, 1872; Lancet, May 20, 1873; Philadelphia Medical Times, September 25, 1875; Dublin Journal of Medical Science, September, 1877.

[4] American Journal of the Medical Sciences, July, 1882.

and projecting in the same direction. The disease is generally amenable to indirect pressure on the femoral, because the chief artery having a little above divided into three main branches, the current in the sac can hardly be powerful. Nevertheless, the cure does not appear to be rapid. It is probable that the Esmarch bandage would have considerable effect; and since, as above explained, the circulation in a sac supplied by a vessel of the size of the posterior tibial, could hardly be very powerful, it would scarcely be necessary to draw the cord very tight. Should these means fail, and should either surgeon or patient desire to avoid the use of the knife, injection with perchloride of iron might be employed; otherwise, unless the sac be placed too high in the limb, deligation of the affected artery may be practised; or, if it be too high, deligation of the femoral, either in Hunter's canal or in Scarpa's space.

*Ligation of the Posterior Tibial Artery.*—Two methods of doing this have been devised: The one—commonly called the "old method"—by an incision near the posterior edge of the tibia; the other, by a long wound in the middle of the calf, through the gastrocnemius and soleus. This last is called Guthrie's method, he having devised it because he had found some difficulty in the other mode.[1] I presume that in the instance or instances in which Guthrie experienced trouble, some severe spasm of the muscles, perhaps some anatomical abnormity, produced difficulty; for the fact is, that, in all the lower three-fourths of the leg, deligation of the posterior tibial artery through an incision behind the tibia is very easy, and few operations less deserve Guthrie's epithets—difficult, tedious, bloody, and dangerous[2]—while to the method which he substituted, such terms might be not unjustly applied. Indeed, Arnott's patient bled freely, and had much cramp and pain.[3] In two instances I have practised the incision here recommended, in order to stretch the posterior tibial nerve for certain painful conditions of the foot. In both I was able to feel, and could readily have passed a needle around, the artery. Barely a drop of blood was lost throughout the one case; in the other I felt what appeared to be a tumor of the nerve, and in using the handle of the scalpel to isolate that cord more completely, a sudden spurt of arterial blood showed that the vessel had been torn. I had no difficulty in passing beneath it an aneurism needle, doubly armed, and in tying the artery above and below the little rent.

Guthrie's operation may be thus described: An incision, six or more inches long, is to be made in the middle of the calf, and the junction of the lateral halves of the gastrocnemius exposed; the separation of these brings the soleus into view. This muscle is also to be severed in the same direction, the operator assuring himself that the whole thickness is divided by noting the easily recognized surface of the deep fascia. The wound through skin and both muscles, held agape with broad retractors, is moved slightly towards the inner side until the whiteness of the nerve is seen through the fibrous tissue, or until its round cord can be felt, with perhaps the pulsation of the vessel beneath it; along this line the deep fascia is slit up, when, the nerve being drawn outward, the artery, with its veins, comes into view. Some difficulty, owing to the depth of the wound, will, in large limbed persons, be experienced in passing the ligature.

Division of the muscular structures causes the incision to constantly fill with blood, increasing the difficulty of the operation, which will be still further enhanced if the ligation has been undertaken to secure a severed

[1] Guthrie never practised this mode. Arnott did so, and, to judge from his description, did not escape tribulation. (Medico-Chirurgical Transactions, vol. xxix. p. 43.)

[2] Wounds and Injuries of Arteries, p. 38.

[3] Loc. cit.

artery at the site of a wound, as in Arnott's case. Hence, before undertaking any such procedure, it is wise to render the part bloodless by means of the Esmarch bandage. I should myself not dream of operating after this manner; indeed, I consider that the large division of parts, and the interference with intermuscular spaces, render this mode unjustifiable, while a method so much less severe, and at least as easy, lies at hand.

The other method, which I very decidedly recommend as preferable, presents no great difficulties. The popliteal artery divides into its three terminal branches about three inches below the middle of the popliteal space. From this point, half way to the malleolus, the vessel is sought from the inner side, under cover of the inner origin of the soleus; below that point the muscle ceases to arise from the bone, and may be pushed aside. The nerve lies superficial, that is, behind the artery, and, except quite at the top of the region which we are considering, to its outer side.

The operator finds the inner, posterior margin of the tibia, and about half an inch behind that line makes an incision 2½ or 3 inches long; this should expose the fascia which covers the soleus, and fixes it to the bone; it also exposes the internal saphena vein (often separated into several branches), which with a little caution, can be turned aside and spared. After division of the fascia, the origin of the soleus, which, except quite above, is aponeurotic, comes into view. A little gap may be made in this, a director passed beneath, and the muscle severed from the bone. On holding the posterior edge of the incision, including the muscle, backward, while the foot is well extended, the anatomist recognizes the long flexor of the toes lying upon the tibia, and covered in by the deep layer of fascia; the finger must be placed on this muscle, and passed on till the nerve and artery are felt—or seen, if the back flap of the wound be drawn well backward and outward. Now the deep fascia should not be divided immediately over these parts, but a little on the inner side; only a slit big enough to admit the tip of the forefinger need be made, as the rest will tear, and then the finger impinges directly on the artery, and may guide the aneurism needle around it, while at the same time it pushes the nerve outwards. The veins should be included in the ligature; they lie close to the vessel, and cross-branches so encircle it that it is barely possible to separate them, while their occlusion does no harm whatever. This operation will serve for any case of aneurism or wound that lies a little below the inferior edge of the popliteus muscle. An aneurism above that point may rank with popliteal aneurisms, and should be treated in a like manner.

A little more than half-way down the leg, the posterior tibial artery becomes less protected; at the lower part of this region, an incision midway between the tibia and the inner edge of the Achilles tendon, will find it lying to the inner side of the nerve, on the flexor longus digitorum. I need hardly add that the deep layer of fascia must be divided. At the upper part of this lower half, the procedure resembles that already described for the superior half of the leg; but the soleus has ceased to arise from the bone, and is only attached to it by a layer of fascia; this being divided, and the edge of the muscle being recognized and turned aside, the artery may be found, and the needle passed as in the higher operation.

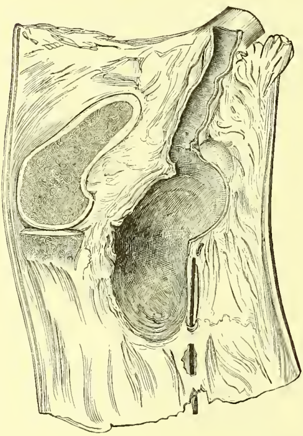
The *popliteal artery* was often tied before the time of Hunter; the operation being no longer employed for aneurism of the popliteal artery, can very rarely, if ever, be required; the only contingency in which I can conceive it to be justifiable, would be in certain cases of hemorrhage from suppuration of an aneurismal sac placed low on the artery (p. 449). The vessel may best be reached from the inner side, by an incision carried just in front of the sar-

torius and semi-membranosus muscles. On division of the fascia, those parts are drawn back with a broad retractor; the strong round edge of the adductor magnus, as it becomes tendinous, is easily recognized, and by cautiously tearing the loose tissue behind that muscle with the finger or with the handle of the scalpel, the artery is easily reached. The nerve does not come into view; the vein is to the outer side, and posterior to the artery.

Popliteal Aneurism.—The treatment of popliteal aneurism must always be, for very many reasons, a matter of great interest to the practical surgeon. It is the most frequent of all aneurisms with which he has to do. It is very variable in its severity, so that the remark which has been applied to all forms of the malady is peculiarly fitting here: "Some aneurisms so tend to cure themselves that very slight artificial assistance suffices to induce their solidification; others obstinately resist one effort after another, and the cure when at last effected may destroy the vitality of parts beyond." It is open to every mode of treatment applicable to the whole range of aneurismal disease, each and every method having been employed successfully and otherwise. Nor is historical interest wanting. It is the first important aneurism in which Anel's method, and the first in which the Hunterian, the flexion, and Reid's method (Esmarch's bandage), were employed.

In making choice of how he shall treat any aneurism at the back of the knee-joint, the surgeon must consider both the local and the general condition of the patient. One would gladly avoid tying a large vessel if milder means will avail, but it is necessary to be sure that the proposed method is milder, or rather that the time which it requires is not so prolonged as to render it both painful and severe. Neither pressure, flexion, nor the use of the Esmarch bandage is painless, and when prolonged, none of them is without its dangers.

Fig. 539.



Popliteal aneurism growing forward.

*Flexion.*—Certain aneurisms being more than others amenable to cure by flexion, it is well to have some clear conception of the circumstances which should induce us to make trial of that method. These are both general and local. The former are early age, not over forty-five or fifty at most; a non-irritable, placid temperament; and absence of the gouty or rheumatic diathesis. The favorable local conditions are, distinct sacculation of the aneurism, which should be of quite moderate dimensions and with somewhat distant pulsation, that is, should be padded with some considerable amount of clot; the sac should in preference be situated at the lower part of the popliteal space, or at least not higher than the middle, for aneurisms which originate and lie on the upper part of the vessel are rarely benefited by this treatment; the sac should also spring from the posterior wall of the artery, and grow backward towards the skin, or at least not forward. When the tumor springs from the front of the vessel and increases towards the bone, it pushes the artery back

so that it does not become sharply bent during flexion of the knee, and the current in it is but little affected, as for instance in the aneurism here shown. (Fig. 539.) In all but large and thin-walled aneurisms the experiment may be made by bending the limb: when pulsation is but little or not at all affected by the amount of flexion which the patient can voluntarily produce, or when bending to an angle of sixty degrees does not annul the aneurismal pulse, the method is likely to be ineffectual.

Flexion must also be contemplated in other aspects, as an adjuvant to other treatment: as perfecting a cure which pressure has commenced, and as an appropriate remedy for recurrent pulsation after ligature.

The majority of cases in which flexion has been used have not been treated by it alone and unaided. Sometimes when indirect pressure has become unbearable, an interval has been granted to the patient, during which, lest the advantage already gained should be lost, the knee has been kept bent; and occasionally during this time the aneurism has become solid, and this has occasionally happened even though, before using pressure, flexion had failed. In some cases this posture has cured an aneurism which did not appear to be, though it probably was, benefited by long-continued, indirect pressure; or again, pressure previously ineffective has after a certain period of flexion cured the disease. Some surgeons have used occasionally with success flexion and pressure simultaneously.[1]

The simplest method of applying flexion is to leave the limb bare, and by means of a slipper, to the heel of which a cord is sewn, to attach the foot to a girdle round the thigh or pelvis. But the method is likely to prove more efficacious if the limb be bent at the hip as well as at the knee, and a proper bandage prevents swelling and sometimes diminishes pain. The limb, exclusive of the aneurism, should be enveloped in a thin flannel or domett bandage; the leg is bent on the thigh, and the thigh on the abdomen; occasionally a pad may be placed in the popliteal space, if it aid in producing pulselessness not otherwise attainable; but the appliance must be cautiously used; it obstructs veins also, and has been productive of gangrene. The methods whereby the limb may be fastened in this position are very various. A mere bandage round the ankle and thigh, though simple, is apt to injure by pressure, or to become unbearable. Some surgeons fasten the ankle near the buttock by means of a belt around the pelvis, and then bandage the thigh to the loins and back. I have found it conduce to the patient's comfort to buckle around the waist and upper part of the pelvis a broad belt, provided with a **Y**-shaped portion inverted, thus **⅄**; the stem of this part is secured to the belt over the anterior superior spine of the ilium. The branches lie one on each side of the thigh. A similar strap hangs behind from just outside the sacro-iliac joint. Each branch bears a buckle. The shin is placed in a leather gutter, like those provided by instrument-makers as slings for the forearm; it is well padded, and provided with straps near the front and back end. When these appliances are adjusted, each to its own place, the ends of the **⅄** in front are fastened to the foremost straps of the tibial sling, and those behind to the hindermost ones, by regulation of the length of each strap; the limb may be restrained in any desirable posture. In New York and Philadelphia, the limb is secured by a belt running obliquely over the shoulder.

In whatever way it be done, the patient will certainly be more comfortable if part of the attachment be elastic, so as to do away with the distressing sense of rigidity, so often complained of.

Patients should be encouraged to lie on the diseased side, the limb comfortably supported by pillows; an occasional change of posture on the back, or

[1] Flexion for recurrent pulsation need not be further mentioned here, see p. 450.

even to the sound side, may be allowed, the limb under treatment being thrown across the other. An advantage, however, is gained by the first of these positions, viz., the possibility of combining with flexion pressure by a weight, after the manner shortly to be described.

This mode of treatment is by no means painless. As already stated, different persons bear it with very varying degrees of tolerance, but no one bears it well when it is rigorously practised. It is more prudent to commence with a slighter degree, even though it may not annul pulsation; after a little while, the further degrees will be more readily borne. Occasionally one of the methods, which to some persons may have been tolerable, will be to another unbearable; yet he may be tolerant of some other mode of fastening the limb. Continuance of one posture is not essential; indeed, some cases have progressed more rapidly and much more comfortably by allowing intervals of rest. In a few instances, when pulsation though much diminished continues, relaxation of treatment has been followed by cure.

In its results, flexion is very capricious. Occasionally the aneurism has so great a tendency to spontaneous cure, that simply lying in bed with the knee spontaneously bent has, in a few hours, produced solidification. On the other hand, many attempts have been abandoned as useless, after weeks of severe and painful treatment. It appears desirable to give the results of treatment as far as my opportunities have allowed me to collect them. In doing this I avail myself of two sources—published cases and hospital records. In using the former, we must accept the numbers with very great caution. Successful cases are almost all published; want of success is rarely made public.

I gather altogether, since the first introduction of the method by Maunoir, 91 cases; of these, 42 have been successful, 49 unsuccessful.[1] Of the unsuccessful cases, 25 came to ligature; 13 were cured by pressure; 4 were amputated; 3 terminated fatally; the ultimate destiny of 4 is unknown.

The causes of amputation and of death were gangrene, suppuration, and rupture of the sac. It must, however, in justice, be noted that flexion was employed alone and by itself in only 26 of the 91 cases, and that of these 19 ended in recovery; this large proportion of cures set down to the method when used alone, indicates merely that a certain number of aneurisms are easily curable; flexion happened to be the method employed; the more recalcitrant cases became subject to successive forms of treatment.

If we pass to hospital reports, more reliable because every case and not merely selected instances are recorded, we find in those six hospitals[2] which I have taken, 7 treated by flexion alone, and 9 by flexion aided chiefly by some form of pressure. Of the 16 cases, 7 were successful, 6 unsuccessful, 2 came to amputation, 1 ended in death.

*Esmarch Bandage.* (*Reid's Method.*)—The Esmarch bandage has been extensively used in popliteal aneurism; its application and its mode of action have already been described (p. 425). I have also taken occasion to remark that its success, when that occurs, is so rapid that it offers a great charm, both to patient and surgeon. The ease with which it can be applied, even by very inexperienced hands, is an additional reason why this method will often be used. It is, however, not without its dangers—the chief and more immediate being gangrene, the less frequent and more remote, thrombosis and inflammation of the sac.

[1] There is no doubt that very many more have been unsuccessful. Often reports of cases state that previous to ligature "other means," or, "pressure and other means," were employed; or some similar phrase is used. I have counted no cases here unless flexion is specifically mentioned. In my collection of cases, Dr. Fischer's table (Prager Vierteljahrschrift, Bd. civ. S. 161) has been used for cases previous to 1869; the rest are due to my own research.

[2] The six hospitals are St. Bartholomew's, Charing Cross, St. George's, Guy's, St. Thomas's, University College.

So much has been said concerning its mode of application and after-management, that nothing need here be added save a statement of results. In the surgical section of the International Congress held in London, 1881, Mr. Gould gave certain numbers, which, being so recent, may be accepted as correct up to the time of writing. I find that, for popliteal aneurism, Reid's method is recorded to have been employed 47 times, and to have been successful 27 times. The 20 cases of non-success include 1 death directly attributable to over-zealous repetition of the treament, causing collapse. One case was cured by proximal pressure; eighteen patients were subjected to ligature, of whom 3 died, 1 submitted to amputation, and 1 had gangrene of the foot.[1] Of the 47 patients, 22 were subjected to the treatment more than once; of these, 1 died and 13 remained uncured.

*Indirect Pressure for Popliteal Aneurism.*—This may be either digital, or may be effected by means of a weight, or by instruments. To carry out the first method (*digital pressure*), a number of more or less trained assistants are necessary,[2] viz., from eight to twelve. They should be instructed to remain, two or three at a time, with the patient, each section to be on duty four hours. No. 1 should keep his hand on the tumor, while No. 2 compresses the artery against the body of the os pubis; it is the duty of the first to warn the compressor of any return of pulsation in the sac. When the assistant restraining the artery is tired, the third man present should relieve him, not by taking his place at the groin, but by pressing on the vessel at the apex of Scarpa's triangle. No. 2 now relaxes his pressure, being in readiness to reapply it if No. 1 gives notice that the lower pressure does not duly control the vessel. At the second change, No. 1, hitherto untired, as he simply has kept a touch on the sac, takes his turn as a compressor. In order to spare muscular fatigue, and thereby prolong the time during which each assistant can hold the vessel, a weight should be provided—either a mould of lead or a bag of shot, weighing from four to six pounds—which is placed on the back of the compressor's fingers.

*Weight pressure* is carried out in much the same way, but without the fingers; an assistant, or trained nurse, should be present, to occasionally feel for pulsation in the tumor, and, if necessary, to readjust the weight. This weight may be of various forms: some surgeons use simply a bag of shot, weighing from 4 or 6, up to 12 lbs.; others employ one piece of lead, so cast as to fit the groin, and another to fit the front and inner aspect of the thigh. Mr. Tufnell is fond of two weights; the one, an oval, has a long diameter of $5\frac{3}{4}$, a short one of $4\frac{1}{4}$ inches. The surface which is next the skin is convex, with a subsidiary protrusion, a sort of nipple; indeed this aspect resembles in form the female mamma; the other surface is flat; the thickness from the centre of the oval surface to the point of the boss is $1\frac{3}{8}$ inches, the weight is 2 lbs. This is laid on the part, so that the projection accurately corresponds to the artery, and upon the flat surface an ordinary weight of from 8 to 12 lbs. is placed. In the use of all weights it is convenient and of great assistance to have them suspended above the bed by a crane-like arrangement; this prevents their falling off when the patient moves, and, if a pulley be supplied, facilitates modifications in the amount of pressure. Either the shot-bag, or the moulded, or Tufnell's subsidiary weight, can thus very easily be slung up. Other forms have, in certain special cases, been used; individual difficulties may be met by commensurate resources.

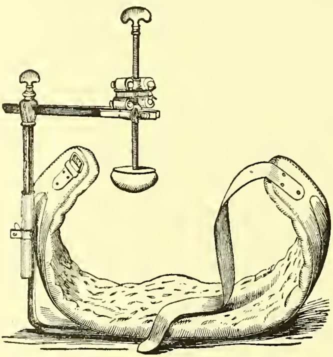
[1] Which coming on four days after deligation, was probably attributable, at least in part, to the previous use of the Esmarch bandage.

[2] In a few rare cases, nature requires so little aid that the patient can himself make all the pressure required; in others, two or three persons are enough; but the rules of surgery cannot be founded on exceptions.

*Instrumental pressure* is capable of almost infinite variety; certain patients bear one form of appliance, which other patients cannot tolerate. I will only mention here those forms which have most generally proved useful. Skey's tourniquet (Fig. 108, Vol. I. page 507) has in a certain number of cases fulfilled its purpose well; it is not adapted for making pressure at the groin; but for parts lower down it is valuable, the ease with which it can be shifted from one part to another being of great advantage, though the pad to receive the back of the thigh is not sufficiently large. Nevertheless, it is often very bearable, and may be used with Carte's compressor, or simply with a weight for the groin. An instrument which enjoys considerable reputation is Signoroni's tourniquet (Fig. 107, Vol. I. page 506); it is in form like a horse-shoe, at whose arc a screw and ratchet arrangement is introduced, and at whose ends the pads for pressure and counter-pressure are placed. A modification of this instrument has been introduced by placing at the pressure end a cross-bar carrying at each extremity a pad; this enables the surgeon to alternate the point of pressure from one place to another. This instrument cannot be used at the groin; the pressure exercised by either of these mechanisms is rigid and unyielding, and hence it is to many patients insupportable. I confess to a strong preference for a larger instrument, such as Carte's, although its complication is certainly no recommendation; but the comfort of the appliance, the method in which it holds the patient, so that the compressor is not likely by accident to become displaced, the ease with which the pressure can be applied and afterwards alternated, and the arrangement of the screw, so that the introduction of strong India-rubber rings enables the pad to spring with each pulsation of the vessel, are great advantages.

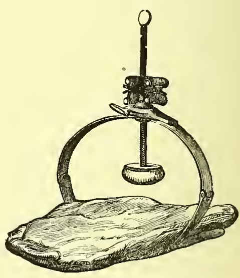
The apparatus consists of two separate portions; the one for the groin, the other for the thigh. The former is a saddle made to fit the back and sides of the pelvis, being comfortably padded to their form. On one side is a rod with a socket, carrying a vertical, and that a horizontal, sliding arm, each

Fig. 540.



Carte's compressor.—Groin portion.

Fig. 541.



Carte's compressor.—Thigh portion.

provided with a binding screw. At the end of the horizontal arm is the compressing rod and screw, the rod running through a ball-joint and double socket connected together by broad flat India-rubber rings, giving a certain play and resilience to the screw. The socket in which the upright arm turns, and that

in which the horizontal works, give means of moving the pad into any place; the ball and socket joint at the end of the horizontal arm enables the tourniquet screw to take any direction. By this means the femoral artery can be compressed fairly against the body of the pubis in such a direction as shall give the most effect to the least mechanical effort, and, therefore, with the least pressure on the skin.

The other part of the instrument is a stirrup-shaped tourniquet, with hinge and clamp at the sides. The arrangement of the tourniquet screw is the same as in the upper or groin portion. The two are intended to be used alternately.

Esmarch has devised a mechanism in which the compressor is a staff or rod of wood, shod with lead, and suspended by an upright and cross piece above the patient's bed, in such wise that a greater or less weight may fall on the vessel, or that the patient grasping the staff may aid its pressure by his own manual force. Esmarch describes this as very efficacious, and of facile use, and gives it the name of "Stangendrück."[1]

In a previous part of this article, the principles which are to guide the surgeon in the use of pressure have already been discussed. I need only repeat here that either the rapid method, with or without anæsthesia, or the gradual method may be chosen; in the former, the artery must be so controlled that no beat of the tumor takes place, while the latter may be more gently regulated. Some surgeons prefer entirely to annul pulsation, and this probably is more certain of producing consolidation, though it is more dangerous, as being likely to lead to ulceration or sloughing of the skin, besides certain other untoward events, such as gangrene, sloughing, or rupture of the sac; while a slight wave of blood through the tumor is by others thought to be advantageous. As a rule, the cases which are subjected to the gradual method occupy the longer time in cure, while those treated by complete occlusion are more liable to relapse.

The *statistics of compression* in its various forms might be made very complicated, if we took separately cases in which any one form was used alone, and likewise the almost endless combinations that were produced by commingling methods—some commencing in one way, some in another; but I think that no good purpose would be answered by such a course. I have found that in taking any one mode, and gathering from publications its results, we get an altogether erroneous proportion of successes, because failure induces the surgeon to try something else. Hence, all the more obstinate aneurisms are treated in a number of ways; those that tend to cure themselves, or that require but little artificial aid, in one way only.[2]

I have collected from American, British, and Continental journals, all the cases I have found, from 1870 to 1879 inclusive. I find that 148 cases of popliteal aneurism have been treated by the various forms of pressure. Of these, 68 were successful, while 80 ended in failure.[3] Of the unsuccessful cases, 57 came to ligature; 9 patients went away declining further treatment, or were dismissed with a still pulsating tumor; 4 suffered amputation; 6 died. The deaths were thus distributed: 1, cause not given; 2, rupture of sac (one of them into the knee-joint); 1, gangrene; 2, thrombosis. The causes of amputation were: 2, rupture of sac; 2, gangrene. Of these cases, 2 died from secondary hemorrhage; 1 from spread of gangrene; 1 survived.

[1] Verhandlungen der Deutschen Gesellschaft der Chirurgie, 4. Congress.

[2] Dr. George Fischer, of Hanover, has given in the Prague Vierteljahrschrift, 1869, S. 167, tables of cases treated by digital compression, gathered from a vast number of journals. The number of popliteal cases is 89; of which 57 were cures and 32 failures.

[3] If from published reports we cull those that are headed as treated by indirect pressure, we get very different proportions. It is among those that are stated to have been subjected to deligation, that the greater number of failures of pressure treatment have occurred.

| | |
|---|---|
| Reduced to decimals, we find of cures . . . . | 45.94 per cent. |
| " " " of failures . . . | 54.06 " |
| Dying with or without amputation . . . . . | 6.08 " |
| Surviving after amputation . . . . . . | 0.69 " |

Few cases are treated entirely by one method. In the intervals of instrumental pressure, either a weight or slight finger pressure is used, or *vice versa;* flexion to a moderate extent may be superadded to either method. I have taken in the 68 successful cases a certain standard for dividing the examples into a more or less conventional series of categories, only placing among the "combined" those in which two or more forms were used about equally, so that one could not be regarded as a mere adjuvant to the other. The longest time of persistence ending in cure was 6 months (digital and instrumental pressure combined). We find among the protracted periods, 6 months, 3 months, 54 days, 7 weeks, 38 days, 4 weeks, 1 month, 3 weeks, 21 days, and so on.[1] The methods employed were respectively the combined, combined, instrumental, digital, weight, staff-pressure, combined, combined, and digital. The shortest period was $4\frac{1}{2}$ hours.

| | | |
|---|---|---|
| Of the cures . . . . . | 26 | were due to instrumental pressure. |
| " " . . . . . | 21 | " " digital " |
| " " . . . . . | 12 | " " combined " |
| " " . . . . . | 6 | " " weight " |
| " " . . . . . | 3 | " " staff " |

| | |
|---|---|
| For *instrumental pressure* the longest period was . . | 7 weeks. |
| " " " the shortest " . . . . | 24 hours. |
| Average of the 19 cases in which time of cure is stated . | 12 days. |
| For *digital pressure,* longest period . . . . . . | 21 days. |
| " " " shortest period . . . . . | $4\frac{1}{2}$ hours. |
| Average period of the 13 cases in which the time is stated . | $5\frac{1}{2}$ days. |
| For *combined pressure,* longest period . . . . . | 6 months. |
| " " " shortest period . . . . . | 44 hours. |

Average period for the 12 cases in which the time is stated, 44 days 8 hours.[2]

We now will take the results as shown in the reports of the six hospitals before named; they are a little more favorable. I find exactly 90 patients treated by pressure in the ten years. Of these, 44 were cured, in 38 the treatment failed, 4 submitted to amputation, and 4 died. Of the unsuccessful cases, 34 came to ligature; the causes of amputation were in 2 gangrene, in 1 rupture of the sac, 1 not stated; 2 of these patients survived. The causes of death were gangrene in 2, exhaustion without gangrene in 1, thrombosis in 1.[3]

*Deligation of the Superficial Femoral Artery for Popliteal Aneurism.*—This operation is rarely practised in Hunter's canal, although in certain contingen-

[1] I give the periods in the words of the authors.

[2] Among the instrumental cases, a few of long treatment run up the average thus high: two, for instance, of 7 and of 5 weeks, respectively. To the combined method, all the most obstinate cases fall. Thus we have 7 very long cases, namely, 6 months, 3 months, 13 weeks, 54 days, 5 weeks, 30 days, 1 month. As already mentioned, this arises from reiterated and varied attempts to cure obstinate aneurisms.

[3] I cannot be sure of the absolute correctness of these numbers; in some of the hospitals, the reports were, for a year or two of the included time, not very well kept; by questioning and abundant reference I have been able to get particulars in some cases; when I have not been able to do so, I have omitted the cases altogether. I should like to take this opportunity of thanking the present registrars of the various hospitals for their most kind and courteous aid, without which it would have been impossible for me to complete the tables whereof the above is a summary; they are arranged for each hospital in the order given. I do not think that I can give the times of treatment with sufficient accuracy to render the calculations reliable, nor shall I follow this plan for other aneurisms save the femoral. Concerning pressure used in the upper extremity, a very few words must suffice.

cies the surgeon may now and then be called upon to tie the vessel in that situation. As a very general rule, the artery is bared just as the sartorius muscle crosses it, and before it gets into the tendinous channel. The guides which I myself follow are two. I bend the patient's knee, abduct the thigh a little, and rotate it outwards just enough to let it lie comfortably upon its outer side, then draw an imaginary line from the centre of the femoro-abdominal fold to the innermost projection of the internal femoral condyle, and another from the anterior iliac spine to the junction of the middle and lower thirds of the thigh. Where these two lines meet, the operator will find the sartorius covering the femoral artery, at a distance averaging in the full-grown man about one and a half inches below the offset of the profunda. Fixing this point in his mind, the operator makes an incision about two and a half inches long, longitudinally down the limb, in such wise that the imaginary point shall be at its middle, or a little below its middle; having cut through the superficial fascia and the fat, often abundant at this place, especially in women, the fascia lata comes into view, and generally one may see through it the outlines of the muscles. That of the sartorius, enveloped by itself in a sheath or fold of the fascia, must be visible before the operator goes further. If, therefore, he does not recognize this, he should move the outer wound from side to side until he finds the muscle's inner edge and knows his exact situation. By passing the knife along the inner margin of the sartorius, and turning the muscle over or drawing it outward, the sheath of the vessel is exposed, generally with the long saphenous nerve running along its outer aspect; this is to be detached and held aside, the sheath of the vessel cautiously opened, and the aneurism needle passed beneath. I do not consider that it matters much which way one passes it, since the vein here lies almost directly behind the artery; the non-inclusion of the vein should, however, be verified. It has once happened to me, and I have seen it occur in the practice of two other surgeons, that in isolating the artery a gush of venous blood has occurred; we all three feared that we might have wounded the vein, and lost a good deal of time in the use of pressure and in looking for an orifice. In all three cases, when pressure was avoided and the artery tied, bleeding entirely ceased.

The operation for tying the artery in Hunter's canal is performed at a rather lower point; the incision is a little more to the inner side, and must be longer. The line from the centre of the groin to the inner condyle is here the guide, but if the saphenous vein be visible through the skin, the knife may be kept in front of it; if invisible, a little caution in the first use of the scalpel will avoid it, and being looked for in the fat, it may be turned aside. The fascia lata, now exposed, lets the sartorius be seen through it; the outer border of the muscle is in this operation to be sought, the fascia divided, and the muscle pushed inward. The structure now revealed is the piece of thin but strong fascia that roofs in, as it were, Hunter's canal, stretching in this place from the vastus internus to the tendon of the adductor longus; this fascia is easily divided; the artery, with the vein a little more on the inner side than it was higher up, and the saphenous nerve close to it on the outer side, is now exposed; both vein and nerve must be avoided by the needle, which may be best passed from without.

The superficial femoral may be tied for aneurism of the femoral artery low down, as in the canal of Hunter, but is more frequently tied for popliteal aneurism. This is of all deligations the most frequently performed, and its statistics stand thus: First, we will take gatherings of published cases; and here I may avail myself of an excellent compilation by Dr. Rabe,[1] who has collected

[1] Zur Unterbindung der grossen Gefässtämme, etc., Zeitschr. für Chirurgie, Bd. v. S. 140.

altogether 259 examples of deligation of the superficial femoral artery, from the time of Hunter's first case to 1873. For reasons which will soon appear, I make use of his table only up to the end of 1869. This gives us 230 cases, of which 187 were cured, while 43 were fatal. To these figures I am able to add for the additional ten years, 1870 to 1879 inclusive, 67 cases with 10 deaths, making altogether 297 cases with 53 deaths—a mortality percentage of 17.8 in the whole period since Hunter first introduced his operation.

Up to 1870, the percentage of deaths was 18.7; since that date, it has been 15.6; but we may go further. A large number of the deaths occurred in the first half of the decade from 1870 to 1880, viz., in 32 cases 7 deaths and 2 amputations (the patients surviving)—a death-rate of 21.87; or if we include the amputations under the head of failures, we have the terrible percentage of 28.1. From 1875 to 1879 inclusive, the mortality declines immensely; we have, namely, 35 deligations with 3 deaths and no amputations—a mortality of 8.57 per cent. I have excluded cases of temporary ligature. I fear we must conclude that numbers obtainable by collecting published cases furnish unreliable and far too favorable results. If we turn to the records of the six London hospitals above quoted, we find a very different death-rate. The number of deligations for popliteal aneurism amounts to 52; of these only 40 were cured while 12 died—making a death-rate of 23.08—a percentage which is certainly higher than it ought to be,[1] and, I firmly believe, very much higher than in a short time hence it will be, that is to say, when the best form of ligature shall have been determined upon and adopted.

This question of the form of ligature is of immense importance; the matter has been already in part discussed, but a few numbers and considerations may here be given. Of the 52 hospital cases above quoted, we must subtract 7 in which the sort of ligature is not specified; the other 45 may thus be tabulated according to the sort of ligature:—

| Substance used. | No. of cases. | No. of deaths. | No. of relapses. | Percentage of failures. |
|---|---|---|---|---|
| Silk . . . . . . . . . . | 14 | 3 | 1 | 21.4 |
| Catgut . . . . . . . . . . | 27 | 6 | 3 | 26. |
| Ox aorta . . . . . . . . | 4 | 0 | 0 | 0. |

Under the head silk, the relapsed patient died; under that of catgut, two of the relapses ended fatally; thus the numbers overlap. There were in the cases tied with silk 3, in those tied with catgut 7 failures.

Causes of death. { Silk, 1 rupture of aneurism at site of ligature; 1 secondary hemorrhage; 1 pyæmia. Catgut, 1 exhaustion and bedsore;[2] 1 erysipelas; 2 secondary hemorrhage; 2 after retying for relapse or fresh aneurism at site of ligature.

If now we consider the ten failures, we find that six, besides one case of relapse in which the patient afterwards got well, were due to the action of the ligature on the coats of the vessel. There would have been no formation of aneurism at the site of ligature, and no secondary hemorrhage, unless the arterial tunics had been damaged. Relapse would have been only an occasional cause of failure if the catgut ligatures had not become too rapidly soft.

[1] It must be remembered that we are dealing with such small numbers that any infelicity of management affects unduly the whole calculation. Thus in one institution whose number of deligations happens to be large, we find that in more than one-fourth of the cases, relapse with ulceration of the vessel occurred, or a new aneurism formed at the site of the ligature. All but one of the patients died, either with or without retying. As such cases are not noted in any other institution, it seems a necessary conclusion that in this one a fashion prevails of pulling the ligature too tight.

[2] The fatal issue in this case was due more to previous prolonged pressure than to ligature.

Femoro-Popliteal, Femoral, and Inguinal Aneurisms.—We now leave popliteal aneurism, and, following the course of the vessel upward, we find that that portion of it which traverses the opening in the adductor magnus is also liable to disease; being situated partly in the thigh and partly in the popliteal space, it is called *femoro-popliteal* aneurism in this locality, and its surgery and statistics are included in those of popliteal aneurism. Above this lies what is termed *femoral aneurism*, under which name is understood merely aneurism of the *superficial* or of the *common* femoral artery. The former of these may occur either in Hunter's canal or in the lower part of Scarpa's triangle; the latter is named after the artery it affects, or, especially if high, is also termed *inguinal.* Aneurism of the *profunda* is called by that name; it is femoral in situation, but requires a distinctive designation; it is a rare malady, and is not usually easily diagnosed from some of the forms above mentioned. A femoral aneurism seated in Hunter's canal may be treated by one of the varieties of pressure, or by flexion at the hip and knee, as well as by ligature of the superficial femoral artery.

*Pressure* may be carried out, if the aneurism be low on the thigh, exactly as has been directed for popliteal aneurism; if higher, only the groin is available for compressing the vessel in the limb; but by a horse-shoe, an abdominal, or a Signoroni's tourniquet, or by a weight, the external iliac artery may be controlled. This treatment is not as efficacious as in popliteal aneurism. I find that since 1869 it has been, according to published accounts, employed 38 times;[1] 10 of the cases were successful, 25 came to ligature, 1 to amputation, and 2 died. Of the 10 successful cases, 7 were treated by complete compression, in 5 with the aid of an anæsthetic. The longest period of treatment in successful cases was 3 days, the next $27\frac{1}{2}$ hours, the pressure of course being at times interrupted. The shortest period was $1\frac{1}{2}$ hours (digital pressure); the average duration of treatment till the aneurism was consolidated was 4 days. The amputation was for gangrene, after 8 days' pressure. Two deaths occurred, both from pulmonary thrombosis and pneumonia—one after 19 hours' compression, and one after treatment lasting 19 days, with intermissions of 6 and 9 days. In one of the successful cases peritonitis had nearly destroyed the patient, and another was cured only just in time, a deep slough having formed which on separation exposed the artery.

In one of the 25 cases that came to ligature, the common femoral was tied, and in one the superficial femoral; catgut was used in both, and both did well. In the others, the external iliac was tied. Of these operations we shall speak immediately.

Turn we now to hospital experience. In the ten years and six institutions already given, I find that 32 cases are recorded, but of two it is merely mentioned that they were in hospital, and one was a doubtful case, which it was proposed to treat by rest; the man thought that he could lie in bed at home, and went away.

| | |
|---|---|
| I have then to deal with . . . . . . . . . | 29 cases. |
| Of these were cured . . . . . | 6 |
| Deaths . . . . . . . . | 4 |

| | |
|---|---|
| The causes of death were: | |
| Rupture of sac . . . . . . . . | 2 |
| Thrombosis of femoral vein . . . . | 1 |
| Thrombosis with pneumonia . . . . | 1 |

[1] Under this category falls the case of femoral aneurism which by pressure was cured in six years, and which, as it was entirely exceptional, I here exclude from my computation of time.

| | |
|---|---|
| The longest time of interrupted pressure was . . . | 4 months. |
| The shortest " " " . . . | $6\frac{1}{2}$ days. |
| The longest time of continuous complete pressure[1] . . | 44 hours. |
| The shortest " " " " . . | $4\frac{1}{2}$ " |

The *Esmarch bandage* may also be made available for femoral aneurisms, especially for those at the lower part of the thigh. In this situation, the mode of application is exactly similar to that for popliteal aneurism. But for high femoral and for inguinal aneurism a different method has been employed—a method, indeed, which is more like rapid indirect pressure than like Reid's method of cure. The flat bandage being applied, the large horse-shoe tourniquet is screwed down on the aorta, or on the common iliac, or on both alternately. The bandage is removed when its pressure becomes too painful; but the tourniquet is retained as long as possible, and then exchanged for digital pressure, when that is available. It is doubtful whether the distal application of the bandage has any effect on the aneurism.[2] The recorded cases treated in this way, femoral and inguinal, are 9; of these 5 were cured, 2 proved fatal (from rupture of other aneurisms), and 2 were afterwards cured by ligature of the artery.

Two of these cases were of inguinal aneurism; one patient died, while the other recovered after one hour's treatment, the case being evidently one of that kind already more than once referred to, which has a tendency to spontaneous cure, and which requires very little artificial aid to enable nature to complete that process.

We will now go on to deligations.

*Ligation of Common Femoral.*—The operation of tying the common femoral artery is not often performed; indeed, it has been by some surgeons entirely condemned, the neighborhood of large branches preventing what has been considered essential for success, the formation of a sufficient coagulum. This point, and the change of treatment justified by the use of soluble ligatures, have already been considered (p. 452).

Two modes of operation are described: the one by a transverse or nearly transverse incision, parallel to and a little below Poupart's ligament; the other by a longitudinal incision over the course of the artery, that is, from the middle of the femoro-abdominal fold downward. I prefer the latter method, since, the superficial branches (epigastric, pudic, and circumflex ilii) being spared, less blood is effused, and the further steps are facilitated. The first incision should expose the fascia lata; this may be divided just outside the line of pulsation, so that, the inner margin being pressed inwards, the sheath is exposed; this is next lifted by forceps, punctured, and then incised on a director, the vessel being thus laid bare in its own particular division of the sheath. The aneurism needle should be passed from within outwards. Unless a high giving off of the profunda can be detected with the finger, it is better not to tie the vessel immediately under Poupart's ligament, but rather lower down.

*Deligation of the external iliac artery* low down is an operation of no great difficulty, and should not occasion much bleeding. It is usually performed by a slightly curved incision above the inguinal canal, which must not be opened. I think that the usual mode, namely, by an incision almost parallel to Poupart's ligament, though it facilitates finding the artery, exposes the

[1] In this case and in another (32 hours), deep and dangerous sloughing took place.

[2] The two cases thus treated belong to Mr. F. A. Heath (Brit. Med. Journal, 1877, vol. i. p. 495), and to Mr. Stables (Lancet, 1879, vol. ii. p. 791). In the one, instrumental and digital pressure was kept up remittently for 36 hours, when the man died. In the other, the flat bandage was used for 30 minutes, and instrumental pressure for 1 hour.

patient almost certainly to the subsequent inconvenience of a large hernia which can hardly be kept back. This danger is minimized by making the incision rather less horizontal. I proceed thus: having found the external abdominal ring, which, in a thin subject, can easily be felt—in a fat man, if its position cannot be so certainly ascertained, the scrotum may be invaginated, and the finger passed into the canal—an incision is begun at a point about an inch outside its outer column, and half an inch above it, and carried an inch on the inner side of the superior iliac spine. This incision should have a slight incurvation, with convexity looking downward and outward. The aponeurosis of the external oblique must be distinctly seen, and incised. Then the internal oblique, and afterwards the transversalis muscle, must be recognized and divided. It is important really to see these parts as separate entities, and the operation is best done by dividing each to nearly the whole extent of the first incision, and in the same curvilinear direction. The operator is greatly helped by a certain tenseness of the abdominal walls; if this be not normally present, an assistant should produce it by pressing gently with his flat hand at and below the umbilicus.

The next step of the operation must be carefully carried out, viz., division of the fascia transversalis upon the peritoneum. The safest plan is to pinch up a little fold with the forceps, incise it with a blade held flatwise, and gently insinuate an oiled director to a little beyond the required distance; before slitting it, the director should be withdrawn about one-quarter of an inch, so as to release a little pucker of the peritoneum, which often laps over the end of the instrument. Now the surgeon, with all four fingers of his hand laid gently upon it, presses the peritoneum, with the bowels, gently over towards the middle line, detaching it from the iliac fossa until he reaches the brim of the pelvis. Here he will find the artery lying just inside the psoas muscle, with the vein on its inner side. The vessel is in a fascial covering, which must be opened so that the artery is really bare; but the operator must spare the genito-crural nerve, which lies generally upon the vessel, a little towards its outer edge.

It should be noted that previous pressure, especially if long continued, renders this operation difficult and hazardous. More than once it has been noticed that by this means the fascia transversalis has become so adherent to, so incorporated with the peritoneum, that it has been impossible to separate them, and that the latter membrane has been necessarily incised. Such wounds are not at the present day necessarily fatal, but they add very much to the patient's danger, and very considerably to the surgeon's difficulty if protrusion of the bowels occurs. Indeed, I have before me the records of three cases in which the intestines had to be held back by an assistant, while the surgeon sought the vessel through the back part of the parietal peritoneum. One of these cases ended in recovery.

The *statistics* of deligation of the common femoral artery are by no means favorable. Dr. Fischer has, in his tables,[1] collected twenty-five operations performed for femoral, five for popliteal aneurism:—

| | |
|---|---|
| Of 25 deligations for femoral aneurism . . . . . | 7 did well. |
| Of 5 operations undertaken for popliteal aneurism . . | 1 " |
| Of 30 deligations of the common femoral artery . . . . | 8 " |
| Recovered after limited gangrene over the sac . . . . | 1. |
| From œdema of lung . . . . . . . . . . . . | 1 died. |
| " gangrene . . . . . . . . . . . . | 2 " |
| " septicæmia . . . . . . . . . . . | 1 " |
| Hemorrrhage occurred in . . . . . . . . . . | 17. |

[1] Loc. cit., p. 194.

Of 17 cases of secondary hemorrhage—

| | |
|---|---|
| Without further deligation | 7 died. |
| After ligature of bleeding ends in wound | 1 " |
| After ligature of external iliac | 3 " |
| After ligature of common iliac | 1 " |
| Without further deligation | 2 recovered. |
| After ligature of external iliac | 3 " |

I can only find since 1872, at which date Dr. Fischer concludes his tables, one case in which the common femoral artery was tied. This occurred in 1879. The ligature used was silk, secondary hemorrhage came on, the external iliac was tied, and the patient survived. Thus out of 31 cases, bleeding occurred in 18, of which 12 died. To place the matter in percentages, the secondary hemorrhages are 58 per cent., and the deaths on the whole series 51.6 per cent.

The hospital experience in this operation is small—indeed, it is repudiated by almost all metropolitan surgeons—so that I find but two cases in the last ten years; both patients died of secondary hemorrhage, one after fresh deligation, the other with pyæmia.[1]

The more usual operation for aneurism of the thigh too high for treatment by occlusion of the superficial femoral, is deligation of the external iliac artery. Dr. Rabe's table gives of such operations 111, of which 26, a little over 23 per cent., proved fatal. My own collection taken from where Rabe leaves off, gives 30 cases, whereof 5 were followed by death, viz., 16.6 per cent., or, taking the whole range since the first operation to 1880, 141 published cases with 31 deaths, an average of very nearly 22 per cent. But these gross numbers require further examination.

Of the 141 cases, hemorrhage occurred in 24; of these 9 recovered, 15 died. Gangrene was observed in 11 (in one of very slight extent); of these 6 died, 5 recovered. Peritonitis occurred in 4, of which 1 died. If we put together the causes of the 31 deaths, we find—

| | |
|---|---|
| Of hemorrhage | 15 |
| Of gangrene | 6 |
| Of peritonitis | 2 |
| Of erysipelas | 1 |
| Of septicæmia | 1 |
| Of exhaustion | 1 |
| Of retroperitoneal suppuration | 2 |
| Of shock and unknown causes | 3 |

The last five headings may be left without further comment. The first three are more important for consideration; I shall not confine my remarks to the fatal cases, for it is desirable also to learn the frequency of unfortunate complications.

Five patients were attacked with peritonitis, of whom only 2 died. It is especially worthy of remark that although the peritoneum was confessedly wounded in seven cases, inflammation ensued in only one instance, and in that the patient recovered.[2]

Gangrene occurred 9 times; 6 of the patients thus affected died—one after amputation—and 3 recovered, namely, 1 in whom the sphacelus had been very limited, and 2 after amputation.

[1] The operation may have been performed more frequently than is said in the text, but it is impossible to found assertions on such phrases as "in a case of femoral aneurism the *femoral artery* was tied." If in the report of a certain large hospital we should accept the italicized words as meaning the common femoral, the number of cases would be six instead of two."

[2] In one case the small intestines and peritoneum protruded, and had to be returned and kept back during the rest of the operation; no peritonitis followed.

In 16 cases, suppuration, gangrene, or rupture of the sac occurred, 7 times with, and 9 times without hemorrhage. Of the 7 patients who bled, 4 died, one after amputation. Of the 9 who had some such giving way of the sac without hemorrhage, only one died, after suffering amputation.[1] Hemorrhage occurred in 21 cases, proving fatal 15 times. In regard to the place whence the bleeding came, we may divide the 21 cases thus:—

| Source of hemorrhage. | No. of cases. | No. of deaths. |
|---|---|---|
| Not specified | 3 | 3 |
| From aneurism | 7 | 5 |
| From above ligature, or above and below | 9 | 7[2] |
| From below ligature | 2 | 0 |

In two cases in the table marked as "not specified," the common iliac was tied; both were fatal. In one case of bleeding from below the ligature, the common femoral was tied with good result. In one case of bleeding from the sac, compression below proved effectual; in one, deligation higher up was useless. In the whole number of cases there were two relapses.

Ten years of experience in the six hospitals already named gave 15 cases of tying the external iliac artery (in reality 18 cases, but 3 are so recorded as to be valueless); of these 6, that is to say, 40 per cent., died. The causes of death were—

| | | |
|---|---|---|
| Pyæmia | 2 | |
| Peritonitis | 3 | (in one the membrane wounded). |
| Secondary hemorrhage | 1 | |

In order to have a larger view concerning the form of ligature, I have put together the cases in hospital reports, and those in published records, in which the substance used is specified; of these I find 43 cases thus distributed:—

| Substance used. | No. of cases. | No. of deaths. | No. of relapses. | Per cent. of failures. |
|---|---|---|---|---|
| Silk | 9 | 2 | 0 | 22.2 |
| Hemp | 5 | 1 | 0 | 20. |
| Wire | 2 | 1 | 0 | 50. |
| Catgut | 25 | 5 | 3 | 32. |
| Ox aorta[3] | 2 | 0 | 0 | 0. |

Causes of death.
- Silk, 1 pyæmia; 1 secondary hemorrhage.
- Wire, 1 "
- Catgut, 1 peritonitis; 2 gangrene and rupture of sac; 2 secondary hemorrhage.
- Hemp, 1 wide-spread peritoneal abscess.

Gluteal and Sciatic Aneurisms.—I class these two forms of aneurism together, because during life it is very generally, and after death it is occasionally, impossible to determine from which of the two vessels[4] that emerge at the great ischiatic notch, the aneurism springs. These affections are rare, but not so extremely infrequent as was a few years ago imagined. Thus some years since, Dr. Fischer, of Hanover,[5] collected thirty-five cases, one of

[1] This does not mean that amputation is not to be practised: it gave the fatally affected patient a slight further chance of life.

[2] 1 of pyæmia.

[3] Of course, in regard to many of the substances, notably wire and ox aorta, the numbers are too small to permit any deduction; while of silk and hemp it may be said that, nearly all deligations previous to 1870 having been done with these substances, all deaths and all successes prior to that date belong to the first two lines of the table.

[4] In the College of Surgeons Museum is a Hunterian preparation, No. 1701, Pathological Series, said by the dissector, Mr. Clift, to be an aneurism of the pudic artery outside the pelvis.

[5] Archiv für klinische Chirurg., Bd. xi. S. 162, 1869.

which was an instance of aneurism by anastomosis, while another, recorded by Dr. Stoker, of Dublin,[1] is extremely doubtful, the observer of that case giving no account of symptoms or appearances. I omit both these cases, reducing Dr. Fischer's number to thirty-three. Since 1869, seven cases have been recorded,[2] making the number of known cases forty. Besides these, there are two instances of a rather different affection termed ischiadico-popliteal, one example of which was recorded in Guy's Hospital Reports,[3] the other by Gallozzi.[4] In this latter, especially, it is noted that the superficial femoral artery was very small, terminating as a little twig just after piercing the adductor magnus. The sciatic artery was large, ran down the back of the thigh with the nerve, and became the popliteal. In these cases the swelling began lower than in those now to be described. The usual aneurism of the buttock forms a tumor, circumscribed or diffused, at the side of that part, and some distance behind the great trochanter; the swelling may or may not pulsate; it usually has some sound, a whirr or a hum, which may in the same case be sometimes present and sometimes absent.

The disease is usually accompanied by very considerable pain, not at all confined to the site of tumefaction, but running forward on the dorsum ilii, downward on the back of the thigh and leg, and sometimes into the perineum. Severe cramps of the leg and sole of the foot are a frequent accompaniment. Thus several of the patients have at first complained of, and without due examination have been treated for, rheumatism, rheumatic gout, sciatica, and even vesical disease.

Aneurisms in this locality are very commonly, as we shall see, the result of injury; hence, they are frequently diffused, even those that were originally circumscribed being very liable to rupture and diffusion. While sacculated, the tumor is rarely larger than a hen's egg, but one or two have been the size of a child's head; when diffused, they may attain to any size, and may extend from the top of the ilium a long way down the thigh.[5]

*Diagnosis.*—Probably the nature of a rounded, circumscribed, murmuring and pulsating swelling at the side of the buttock, is, in spite of its depth, as easily recognizable as in any other situation; but the disease does not by any means always manifest itself thus, and when there is neither bruit nor pulsation, the diagnosis is undoubtedly difficult, so that many disastrous errors have been made. Aneurism of either the gluteal or sciatic artery is most likely to be confounded with abscess, tumor of bone, and perhaps with sciatic hernia.

*Abscess* in this situation is more common in young persons than in those beyond 25 or 30 years old. It may arise from hip disease, from caries of the lowest lumbar or sacral vertebræ, or from sacro-sciatic disease,[6] as also from suppuration of the subgluteal bursa. A deep, circumscribed abscess in this situation is never a mere localized suppuration, but is combined with symptoms of caries at one or the other locality above named, the pus finding its way out of the pelvis along the pyriformis muscle through the sciatic notch. If the abscess be merely in the subgluteal bursa, it has little definition, is more widely diffused, and makes of the nates a sort of bag, which hangs lower without implicating the thigh than does an aneurism. If doubt remain (and this latter form of abscess may very closely simulate a diffused, non-pulsating

[1] Trans. of the Association of Fellows and Licentiates, etc., vol. i. p. 41, 1817.

[2] Bickersteth, Kade, Baher, Landi, Coluzzi, Scauffoni, and Gallozzi.

[3] Hilton-Fagge, 1864.

[4] Lo Sperimentale, Febbrajo, 1874.

[5] See John Bell's cases, and more recently Kade's case in St. Petersburg Med. Wochenschrift, 1876, No. 89.

[6] See the author's work on Diseases of the Joints, in Wood's Library of Standard Medical Authors, p. 315, and the article on Joint Disease in this Encyclopædia.

aneurism) the aorta must be compressed and the variations in size of the tumor watched (see p. 396). If the case be still ambiguous, a fine exploratory trocar should be employed.

To distinguish between gluteal aneurism and *malignant tumor of bone*, is extremely difficult. They both may or may not pulsate; but a growth from bone alters the shape of the part by raising ridge-wise around its stalk the outer crust or table, and has generally within it osseous spiculæ. These characteristics have been already sufficiently pointed out (p. 397). I need only add, that examination through the rectum is an immense aid in diagnosis, and that if by the mere introduction of one finger no distinguishing marks can be discovered, it may be necessary, for reasons which will be given presently, to insert the whole hand.

*Sciatic hernia* is an extremely rare condition. If it be reducible while the aorta is unobstructed, there can be no difficulty in diagnosis; if irreducible, it will probably be, in part at least, flatulent, and on percussion will give the characteristic note. Impulse on coughing, though slight, is also to be detected, and the peculiar gurgle on pressure will almost always be felt. Moreover, though it may, as a rarity, be irreducible at the time of examination, rest in bed for a day or two will probably diminish its size, even if it do not entirely go back. I am not aware that in the records of surgery any case of incarcerated or strangulated sciatic or gluteal hernia has occurred.

The symptoms, history, and circumstances of gluteal aneurism are as follows. A large proportion of these cases are due to some form of injury, thus:—

| | |
|---|---|
| Spontaneous | 12 |
| Penetrating wound | 16 |
| Falls and blows[1] | 10 |
| Caries (sacro-iliac)[2] | 2 |

A swelling, accompanied by pain and lameness, which comes on a few days after an injury, may easily be mistaken for an abscess; and proportionally to its frequency, more mistakes have been made in cases of this particular aneurism than of any other. In most of these, however, there is at first some sound, at one or another part of the tumor, and generally over the sciatic notch more distinctly than elsewhere. The surgeon should not be content with a single auscultation if there be no murmur, but should search, on several successive days and in different positions of the limb, both for sound and pulsation. The rock on which diagnosis is most easily wrecked, is when there exists an aneurism with neither pulsation nor bruit. The surgeon must endeavor to empty the tumor when the aorta is compressed. Even in doing this some cautions must be given, for an abscess, by gravitation, may be partially emptied by pressure from the outer parts into the interior of the pelvis; but this will be as easy when the aorta is free as when it is compressed. This in itself is diagnostic; for a tumor which can thus be rendered flaccid and small under compression of the aorta, but not otherwise, is clearly not an abscess. Examination by the rectum should in all cases be made. Generally the introduction of the finger merely is insufficient, but with the three outer fingers—or, when necessary, with the whole hand—the sciatic notch may be felt, as also the iliacs and a great part of the front of the sacrum. Now, in this way one may detect the roughened surface of caries, or, perhaps, an aneurismal prolongation into the pelvis, or one may feel the vessels to be normal; or, on the

[1] I have already called attention to the doubtful meaning of the word traumatic. It would certainly be greatly to the advantage of surgery if we had one word to indicate wound, and another to mean injury without wound.

[2] I think that in one of these cases the caries was due to and not produced by the aneurism; the other is, perhaps, as given in the text.

contrary, a bag of purulent fluid, fluctuating from without to within the cavity, may be discovered. The first condition only is absolutely diagnostic; the others, however, greatly aid. The same investigation should be made if there be doubt concerning some tumor of bone. It is hardly possible that such a tumor should be marked on the outside of the pelvis without giving some sign within the cavity. In many cases all care and acumen will still leave some ambiguity, which the use of a fine exploratory trocar will set aside. When thus employed, positive evidence—that is, the appearance of pus—must be obtained before any such adventurous measure as incision is practised.

*Treatment.*—Several methods of treatment are open to the surgeon, the most important being (1) Rest and expectancy, (2) Pressure, (3) Injection, (4) Opening the sac (Antyllus), (5) Tying the gluteal or the sciatic artery as it leaves the pelvis (Anel), and (6) Deligation of the internal iliac artery.

(1) The first (*expectant method*), provided the aneurism do not grow, may be carried on as long as the sufferer's patience will last; but these aneurisms do not long remain stationary.

(2) *Direct compression* and *proximal pressure* on the aorta have not proved of value. In one case,[1] indeed, a certain improvement took place; but in three years the aneurism returned.

(3) *Injection of a coagulating fluid* (perchloride of iron) has proved valuable when the aneurism has been distinctly sacculated.

(4) *Opening the sac* and tying the vessel below the tumor, and also above, that is, at its exit from the sciatic foramen, may be undertaken under certain circumstances. Thus if the disease have been produced by recent injury, it probably affects only some part of the artery lying outside the pelvis, in which case the procedure in question will be applicable; but even an aneurism thus produced, and the more likely if it be of some little standing—and still more probably if it be of spontaneous origin—may extend beyond these confines, and a portion of it may be within the pelvis, and thus beyond reach. If by any chance the Antyllian method were used in such a case, death could hardly be escaped; therefore no such operation should be undertaken unless previous rectal examination had shown the artery to be sound.

(5) *Anel's Method.*—If the vessel be found healthy, either deligation of the sciatic or gluteal, as the case may be, can be undertaken with some little prospect of success. In either procedure one of the vessels above should be commanded; the aorta can usually be efficiently compressed in a thin person; if the individual be stout, Davy's lever will insure entire, or almost entire, bloodlessness. My own experience of this instrument is not very favorable; it is apt to produce bruising and inflammation of the iliac vein. The surgeon undertaking either operation ought to know that the sac lies much nearer to the surface than would *a priori* be supposed: the gluteus becomes spread out over it, the fascia becomes much thinned, and even the fat of this region may, to a great extent, disappear. The aneurism may be divided by a constriction into two portions ("hour glass"), or may split into prolongations ("digitated") in the direction of branches. The mouth of a sciatic aneurism lies lower than that of a gluteal, and in attempting to secure the vessel after the method of Anel, much difficulty may be experienced in deciding which of the two arteries requires deligation.

(6) *Deligation of both the internal and common iliac arteries* has been practised for this aneurism, but the results are not encouraging; the latter operation would of course only be undertaken if the condition of the internal branch rendered the application of a ligature to it injudicious or very difficult.

[1] Riberi, Giornale delle Scienze Med. di Torino, 1833.

The results of these various methods are:—

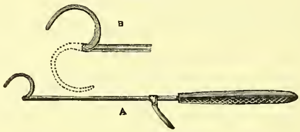
| | Cure. | Death. |
|---|---|---|
| Rest and expectancy | 1[1] | 5 |
| Pressure (direct and proximal) | 0 | 2 |
| Injection of perchloride of iron | 4 | 2 |
| Old operation (Antyllus) | 4 | 1 |
| Deligation of artery outside pelvis | 2 | 2 |
| " internal iliac | 6 | 10[2] |
| " common iliac | 0 | 2 |
| Galvano puncture | 0 | 1 |

To tie either the upper part of the external, the internal, or the common iliac artery, the operator must go through the same steps up to the time of his reaching the vessel. The incision should commence a little below the level of the anterior superior spine of the ilium, and about an inch inside it; then it should be carried upward for from four to five inches, the cut, however, not running straight between these points, but sweeping backward with a free outward curve, so that the extent of skin passed over by the knife is considerably greater than the space between the ends of the incision. The outer muscle of the abdomen is thus brought into view, and may be divided in the same curve, and then the internal oblique and the transversalis are to be similarly dealt with. It is not necessary to use the director, certainly not for the outer two muscles; but each layer should be distinctly recognized. After division of the last-named muscle, the transversalis fascia is exposed; sometimes it is very thin in this place, and the operator may be in some doubt, but he must entirely orient himself before going on. Let him turn up the transversalis muscle, and, examining its deep surface, ascertain if the fascia have been incised with it. He should remember, too, that this structure is of a slightly bluish-gray—that between it and the peritoneum is an unevenly distributed layer of granular fat—and that one can dimly see the viscera through the serous membrane when bare, but not through the fascia. When he has decided that the structure in question is uncut, he must divide it on the director, and will find it easier to begin below, where it is thicker, than above, where it is thin and less distinct in structure. The peritoneum being exposed in the length and curve of the first incision, the surgeon now presses it gently towards the middle, taking care to separate it very carefully, and not too quickly, from the parts behind; if he be intending to tie the common iliac, he should aim at the upper margin of the sacrum; if one of the branches, a little lower: in the one case, he will carry his finger along the crest of the ilium and the parts above; in the other, along the back part of the iliac fossa. Thus going on, the operator, when his hand gets near the sacrum, feels the great artery beating in the depths of the wound; the ureter and the spermatic vessels will in all probability have remained attached to the peritoneum, and, being turned aside with it, are out of danger, but it is well to make sure of this by touch or sight before going further. Supposing that it is the common iliac which the surgeon intends to tie, he will find the artery lying just inside the psoas muscle, and may, by passing his finger gently downward, feel its bifurcation (the vessel, unless for very high aneurism, should be secured at its lower end), which will assure him that he is really at the intended spot. But the artery is still covered by a layer of fascia, which must be scratched through with a director, the aneurism needle, or, as I prefer, with the finger-nail. At this point, the operator must bear in mind, that on the right side the iliac vein lies outside, on the left, inside the artery; in other words, that the vein is to the right for both lateral halves of

[1] Spontaneous relapse. [2] Five of these operations were undertaken in hopeless conditions.

the body; so also the needle must be passed on either side from right to left. A difficulty is experienced sometimes in getting the instrument sufficiently far around the vessel to release the ligature, or to arm the needle, as the case may be. I have devised a needle which obviates this trouble (Fig. 542). The

Fig. 542.




Aneurism needle with hinged end.

lower, curved end being mounted on the shank by a hinge, can be projected forward by pressure on the trigger; so that without moving the handle or body of the instrument, the eye can be made to pass around the vessel.[1] If the upper part of the external iliac is to be tied, the vessel will be found a little nearer the surface; on the left side, the vein is inside; on the right, behind the artery; the needle is used lower down in the wound.

The short trunk, termed internal iliac or hypogastric, lies a little further inwards; the peritoneum must be pushed back nearly to the middle line, the bifurcation of the common trunk distinctly felt, and the vessel traced thence in front of the sacro-iliac joint; the artery should be tied as low as is feasible. The way in which, on the left side, it crosses over the vein must be borne in mind, lest the instrument, being carried too far back, should wound or include that vessel.

## Abdominal Aneurism.

The description of tying the internal iliac artery has forestalled somewhat what is to be said in connection with this subject, but to have separated it from deligation of the other iliacs would have necessitated a troublesome repetition, whereas a retrospect only is now needed. The internal iliac may require ligature for aneurism about the buttock; the lower part of the external iliac for femoral aneurism; the upper part of the same vessel for aneurism in the iliac fossa; and, if the sac of the aneurism rise high, it may even be necessary to occlude the common iliac just above its bifurcation.

But the latter vessel may also be tied, or, at least, the operation comes into consideration, in cases of aneurism lying somewhat low in the abdomen. The division of the aorta into the common iliacs takes place below the middle of the fourth lumbar vertebra, and clinically, and on the living body, may be taken to lie about three-quarters of an inch below the umbilicus; hence we may roughly assume, unless evidence to the contrary be adduced, that aneurisms pulsating below that point are of the common iliac artery, and those above it of the abdominal aorta, or of one of its branches; the branch most often thus affected is the cœliac axis, the next the superior mesenteric.

A few words must here be said concerning *pulsating tumors of the abdomen* and their diagnosis. It is well known that, in some persons, pulsations of the abdominal aorta may be felt on the surface of the abdomen with startling

[1] This instrument was devised for tying the subclavian artery in a person whose clavicle was much raised.

distinctness; especially is this the case with hysterical young women, and also in cases of albuminuria. The normal line in which this aortic pulse may be felt, with the unaltered beat of the femorals, should prevent any mistake as to the diagnosis. But the fact that such an exaggeration of beat may, under certain circumstances, occur, shows that caution is necessary in pronouncing as to the nature of any tumor overlying the aorta, even though it pulsate very strongly. Bruit is very frequently absent in abdominal aneurism; while a merely hysterical, pulsating aorta may possess a distinct, though not loud, murmur. No conclusion, save in very evident and plain cases, should be formed until a purge and an enema have thoroughly cleared out the bowels. The examination should be made, not merely while the patient is on his back, but also while he is on his side; so that the surgeon, gently kneading the intestines away, may get his hand more directly on the vessel, and so that any intestinal impaction, or mesenteric or omental tumor, may fall away from the front of the vessel. If, under these circumstances, an ovoid or globular pulsating tumor remain stationary, or nearly so, the suspicion of its being aneurismal is in so far confirmed; but it must be remembered that malignant tumors of the lumbar spine or glands, or of the kidney, and even a pyo-nephrosis or a hydro-nephrosis, may pulsate;[1] and the possible presence of each of these conditions must be eliminated by careful and repeated examination.[2]

The pressure symptoms of abdominal aneurism, being due to compression of certain viscera, or of their ducts, are not very dissimilar to those caused by disease of the organs themselves. Thus, we may have pain in the back, with caries of the spine, and even psoas abscess; loss of flesh, sickness, distension, etc., from intestinal pressure; the same set of symptoms, with severe jaundice, from obstruction of the hepatic ducts; or intense renal troubles from involvement of the ureter. Such conditions, if taken alone, are not in any way characteristic; but if conjoined with the presence of a pulsating tumor, they may greatly aid diagnosis.

Aneurism of a branch at a little distance from the parent trunk is distinguishable by the mobility of the whole tumor; this is more especially the case if either mesenteric artery be involved, but if the aneurism spring from a branch close to the main vessel, and a portion of it involve the actual mouth of the artery, no such distinction can be drawn.

The *treatment* of abdominal aneurism is by no means attended by very satisfactory results. The method of Valsalva should first be tried, without the bleedings, or, at all events, without the copious and repeated bleedings recommended by that surgeon. A certain hopefulness is imparted by the fact that a certain number of these aneurisms, some of them unsuspected during life, have undergone spontaneous cure. The rest should be entire, the patient being prohibited from rising or turning in bed without assistance; even the thighs and legs should be kept very still. Some aid, and in such cases even the slightest assistance should be sought, may be obtained by raising the foot of the couch so that the pelvis and nether limbs may be some inches above the shoulders, and that thus the force of the blood-stream may be diminished by gravity. Atropia, aconite, or digitalis, may be given alternately according to circumstances, and I have had reason to assign much benefit to their use. All these drugs must be administered with caution, for though slight nausea may be induced, emesis is to be avoided; a single act of

[1] Occasionally, though very rarely, abdominal aneurism does not pulsate; under which circumstances it may be almost impossible to make a diagnosis, save after long watching.

[2] Some caution should be given concerning much kneading or pressure on these tumors. Too great an amount of force may, and indeed has, caused rupture.

vomiting may, especially if the aneurism be placed high, undo the work of many months, and may perhaps even add a fresh increment to the disease.[1]

After days of this treatment, or even after weeks, if progress be slow, only one of three courses is open to the surgeon: (1) To leave the patient to his rapidly approaching fate; (2) To try the effect of pressure; (3) To ligature the aorta. The choice between these depends in great measure on the place whence the tumor springs, and the height in the abdomen to which it rises.

*Distal pressure* has never yet proved of advantage in aneurism of the abdominal aorta; so many branches are given off from this short tract of the vessel, that it does not seem theoretically possible to sufficiently restrict the circulation by means[2] which practically have proved unavailing. I know of but three cases in which this plan has been tried: one proved fatal by bruising of the peritoneum and intestine, and in the other two no benefit accrued.

*Proximal pressure* may be applied in abdominal aneurism, provided that the sac be placed low enough to admit a tourniquet pad between it and the diaphragm; in other words, if it be on a level with or below the inferior mesenteric artery, and if its beat be not much above the umbilicus. Thus aneurisms of the common iliac, or of the upper part of the external iliac arteries, may be so treated, as well as those of the aorta a little above its bifurcation; but five-sixths of aortic abdominal aneurisms arise from the part whence the cœliac axis and the superior mesenteric artery are given off, that is to say, so high that the use of proximal pressure is impossible.[3]

To Dr. Murray, of Newcastle,[4] belongs the credit not only of a first attempt, but also of a first success in this method. Dr. Moxon and Mr. Durham afterwards cured a case of abdominal, probably mesenteric, aneurism by proximal pressure continued uninterruptedly for ten and a half hours.[5]

The instrument employed is either the abdominal tourniquet of Dr. Pancoast (Fig. 111, Vol. I. p. 568), or the aortic compressor of Mr. Lister (Fig. 112, Ibid.). The patient must be prepared by a thorough cleansing of the bowels with medicine and enema. The safest place for the application of the instrument is probably about midway between the umbilicus and the scaphoid cartilage, or a little higher, but not as high as to endanger either the pancreas or the duodenum where they cross the aorta. The intestines should be carefully kneaded and pressed away with the hand as much as possible, and then the fingers are to press the abdominal wall backwards towards the spine, and the pad is to be screwed down upon them. Then, when the fingers are withdrawn, the tourniquet is to be screwed down very slowly, so as to give the viscera ample time to escape to either side.[6] No stronger pressure than is needed to command the pulsation of the aneurism should be employed, and if that be persistent, it may be wiser to permit a slight wave than to use very much force. A fair guide will be the behavior of the femoral artery, whose beat is often annulled before that of the aneurism. Owing to the want of circulation in the nether limbs, good covering with artificial warmth must be supplied. Since pressure sufficient for the purpose cannot possibly be borne by a conscious patient, some form of anæsthetic must be employed; and since fits of severe vomiting are to be avoided, such agents as are least likely to induce that condition should be chosen; and also, since the anæsthesia, though it need not be deep, must be prolonged, it is generally desirable to

[1] As far as I can find, three cases only have permanently benefited by this treatment.

[2] This is not strictly correct in regard to the common iliac, but the internal iliac would afford current enough to render compression of the external iliac futile.

[3] See Sibson's Medical Anatomy, p. 58.

[4] Medico-Chirurgical Transactions, vol. xlvii. p. 187.

[5] Ibid., vol. lv. p. 21.

[6] Even when the pressure is made quite low down, a coil of intestine may become involved, as in Bryant's case (Med.-Chir. Trans., vol. lv. p. 225).

vary these, so as to neither too greatly depress nor excite the heart's action. It must also be remembered that by forcing the abdominal muscles against the spine, the movements of the diaphragm become immensely impeded. The action of the heart is apt to be embarrassed, not merely from this cause, but also because a great part of the blood which ought to flow through the abdominal aorta to the lower limbs, is now retained in the upper aorta and its branches; there is in the upper part of the body a local plethora, yet the fear entertained some years ago, that the brain might suffer from this mode of treatment, appears to be chimerical.

One very imminent danger, which has been illustrated by more than one death, is bruising of the peritoneum, of certain viscera, or of both. The pancreas and duodenum have both been almost pulpefied by incautious application of the tourniquet at a point too high for safety. Other portions of the intestine have also been severely injured. Below the duodenum, no fixed viscus overlies the aorta, and here, partly by kneading the intestines away with the fingers, partly by screwing the pad very slowly down, so as to press those parts away, pressure upon the bowel may sometimes be avoided; that on the peritoneal surfaces is of course unavoidable. The compression must be strong enough to annul, if possible, all pulsation of the aneurism, and that of the femorals at the groin must also be suppressed. The femoral pulse may be taken as a guide to show when the compression is sufficient. In some cases, the aneurismal pulse will not entirely disappear, but when the femorals have ceased to beat, it is not safe to turn the screw much further.[1]

Pressure made in this way has been kept up with the aid of anæsthesia for five, ten, and ten and a half hours.[2] During the whole time of treatment, the greatest watchfulness must be exercised over the condition of the patient, in several directions—as to the effect of the anæsthetic, the state of circulation and respiration, the condition of the lower extremities, and any movements which might cause the instrument to slip. It will be necessary, all this time, to watch for pulsation both in the femorals and in the tumor; if the aneurism, during maintenance of pressure, get harder and smaller, much hope may be entertained that a cure is going on; but the pressure should still be continued for at least four or five hours. When compression is stopped, the tumor may appear unchanged; and then, if the patient can bear it, a further attempt may be made.[3] The aneurism may have but very slight or no pulsation, but this may, in a few hours, to a certain extent, return. Under these circumstances it is wise to leave the patient at rest: the cure once begun may complete itself, and a non-increase of pulsation shows that the case is doing well. This consecutive mode of cure followed in the case of Durham's and Moxon's patient.

The recorded cases treated in this way are but few: doubtless more have failed than are made available by publication, but we may conclude with almost complete certainty that all successful instances are known. Ten cases are recorded, of which five were successful; in one of these the aneurism was of the external iliac artery.[4] In five cases the treatment failed, death resulting in four.[5] All the deaths were due to peritonitis and bruising of the

[1] Entire suppression of urine during pressure cannot be without danger; hæmaturia is less important, unless from injury to the kidney.

[2] Murray, Heath (of Sunderland), and Durham.

[3] In the famous Sunderland case, pressure, not quite continuous, was employed for ten hours, when the patient fainted, the tumor seeming in no wise improved; he submitted to a further trial without any anæsthetic, and the aneurism solidified in twenty minutes. (Brit. Med. Journal, Oct. 5, 1867.)

[4] Wheelhouse, Clinical Society's Trans., vol. viii. p. 57.

[5] One of these is unpublished; it occurred in the practice of Mr. Hird, at the Charing Cross Hospital.

abdominal contents. Of the fatal cases, one involved the superior mesenteric artery. In a non-fatal case gangrene resulted, the external iliac was tied, and amputation performed. Agnew records a successful compression of the common iliac for aneurism of the external iliac artery.[1] Three cases of distal compression of the aorta have failed, one under Marshall's, and another under my own care, while the third[2] terminated fatally from the usual cause, bruising of the viscera and peritoneum.

*Deligation of the abdominal aorta* has hitherto, in the human subject, proved invariably fatal. Whether surgery is permanently to accept the defeat, we shall consider in the sequel.

Astley Cooper first performed this operation in June, 1817, on a man thirty-eight years old, who, having aneurism of the external iliac artery, suffered profuse hemorrhage after pressure, which involved the sac. The operation was performed through the peritoneum, and the man lived 40 hours. The latest case is that recorded by Czerny, of Heidelberg, in 1879, for hemorrhage after extirpation of the kidney. In all, there are on record 10 cases: 4 undertaken for hemorrhage (2 secondary, in aneurism), and 6 for aneurism without hemorrhage. Cases of the former class are very unfavorable, even when much smaller vessels are tied. Of these 10 cases 6 were, if the phrase be allowable, foredoomed to death, either by concomitant disease, or by mishaps during the operation. Taking these cases in chronological order, the complications were:—

| | |
|---|---|
| 1. Escape of inflated intestines; breakage of aneurism needle, and long search for it among folds of mesentery; insufficient care in closing bleeding vessels, | Death in 4 hours. |
| 2. Bladder disease; dilated ureter . . . . . | " " 23 " |
| 3. Bursting the sac by manipulation; inclusion of the ureter in the ligature . . . . . . | " " $11\frac{1}{2}$ " |
| 4. Fatty degeneration of heart[3] . . . . . . | " " 13 " |
| 5. Very complicated injury, caused by the previous condition rather than by the operation, which terminated in a different procedure from that originally intended . . . . . . . . | " " 26 " |
| 6. Malignant disease of kidney; nephrectomy . . | " " 10 " |

A very unfortunate list, of which it can only be said, that in four of the cases death would probably have followed smaller operations, while in the two others either inherent difficulties or insufficient skill, rather than the necessary sequelæ, led to a fatal result.[4]

In the only four cases which were free from unfortunate and unnecessary complications, the patients survived for 40 hours, 43 hours, 65 hours, and 10 days 21 hours respectively—lapses of time more than sufficient to show that the chief theoretic objection, viz., oppression of brain and heart through overfulness of blood, is no necessary result of the operation, even though, as in Cooper's case, the vessel be tied above the duodenum. The causes of death in these four cases are, therefore, of the highest degree of importance; unfortunately they are not all obtainable.

The first patient (Cooper's) died unmistakably of peritonitis; nor can we take as a negative its apparent absence on post-mortem examination, because the earliest signs of that condition are not easily detected, while in this in-

[1] Philadelphia Medical Times, Sept. 4, 1875.
[2] Bryant, Medico-Chirurg. Trans., vol. lv. p. 225.
[3] A more necessarily fatal complication can hardly be conceived.
[4] The subject of the fifth case in the above list (Czerny's, of Vienna) died of sloughing of the injured part, together with the admission of air or gas into the open veins. The morning after the operation, he smoked a cigar with pleasure.

stance the symptoms were exceedingly characteristic. (Intra-peritoneal operation.)[1]

The next patient (South's) lived 43 hours. The case is very insufficiently reported, the only note that I can find of it being: "The young man went on remarkably well after it, but he died on Monday morning, surviving the operation 43 hours." (Extra-peritoneal.)[2]

P. Heron Watson's patient survived 63 hours. The operation was undertaken for secondary hemorrhage, after deligation of the common iliac. This case also is very shortly reported. The patient died of exhaustion. (Intra-peritoneal.)[3]

Monteiro's patient lived close upon 11 days, and died of secondary hemorrhage.[4] If the operator had been possessed of one of the fresh animal ligatures recently introduced, the man would probably have recovered.

It must, therefore, be concluded that deligation of the abdominal aorta has hitherto been very unfortunate as to the accompaniments of the cases in which it has been tried. It does not deserve, therefore, to be condemned and banished, but under pressing circumstances may be resorted to, the operator employing the extra-peritoneal method, and using such a ligature as will obviate the risk of secondary hemorrhage. This is demonstrable from the results of Monteiro's, and in a less degree by those of the other three comparatively successful cases.[5]

## Aneurisms of the Upper Extremity.

Aneurisms of the Palm and Wrist.—These are nearly always traumatic, and may be exceedingly troublesome, since the very free inosculation of vessels occasionally frustrates attempts at cure. All the means which have been detailed in previous sections are, however, available. But the surgeon would probably first try either the Esmarch bandage, or some form of pressure on the brachial artery. Flexion, with a pad in the bend of the elbow, has been successful in arresting hemorrhage and in curing consecutive aneurisms. Deligation of one, or of more than one, of the afferent arteries, is but a slight operation, and is very usually successful. Incising the sac and securing both ends has also availed; but three cases are on record in which, after such an operation, the palm suppurated, the carpus became carious, and, in two, amputation was performed. Nor can I commend extirpation by chloride of zinc or other cautery. If none of the various forms of pressure cures the disease, deligation is the least severe method, and the one most unlikely to be followed by evil consequences.

For an aneurism in the palm, which will not yield to compression, it is probably the best practice to tie both the radial and ulnar arteries a little above the wrist.[6] The operation on either vessel, low down, is extremely simple. The radial is easily accessible throughout its course.

[1] Cooper and Travers, Surgical Essays, Part i, p. 201. [2] Lancet, 1856, vol. ii. p. 47.

[3] British Medical Journal, 1869, vol. ii. p. 216.

[4] Schmidt's Jahrbucher, Bd. xxxvii. S. 85.

[5] Space will not allow me to consider here all the arguments that have been adduced either for or against the operation. Pirogoff's well-known experiments (Waller und v. Gräfe's Journal, Bd. xxvii. S. 122), and those of Kast in his excellent paper (Zeitschrift für Chirurgie, Bd. xii. S. 405), show that the collateral circulation becomes established, and that the supposed injurious effects on spinal cord and brain—the one from excess, the other from absence of blood—are chimerical.

[6] If any prolonged pressure has been made upon these vessels, the deep branch running to the carpus from the anterior interosseous, and probably other side channels, will supply too much blood to the part. In a case under my care—of hemorrhage from a wound of the palmar arch, caused by the bursting of a soda-water bottle—the vessel had twice been tied in the wound.

*Ligation of the Radial Artery above the Wrist.*—Midway between the tendons of the supinator longus and flexor carpi radialis, a longitudinal incision, from an inch to an inch and a half in length, should expose the fascia of the arm, and with the finger moved from side to side the skin and subjacent tissue should be pushed away, so that a little breadth for examination is obtained. Through the thin but firm fascia, the artery and its companion veins are usually visible; if not, the vessel may be felt pulsating. Just at the inside of these parts, the fascia may be pinched up with forceps, opened, and slit up on a director to the length of the first incision. The nerve has left the vessel at this point, and does not require consideration. If the operator think it necessary, which it is not, he may separate the companion veins.

*Ligation of the Radial Artery in its Upper Portion.*—The operation on the vessel higher up is quite as simple. The artery takes a straight course from the biceps tendon to the inner edge of the radial styloid process. In the middle third it may be overlapped by the belly of the supinator longus, which may, after division of the fascia, be drawn outwards. The nerve, which is nearer the vessel in the middle third than elsewhere, should be pushed in the same direction, and the needle is to be introduced between it and the artery.

*Ligation of the Ulnar Artery.*—To tie the ulnar artery above the wrist, the tendon of the carpal flexor may be taken as the guide. The incision must be made just outside its outer edge, deep enough to lay it bare, and to enable an assistant to hold it inward with a blunt hook. The artery and the nerve will then be seen, the latter on the inner side; but the vessel is not yet bare, being held down to the common flexor by a fascial covering, which must be divided.[1]

In the middle third of the forearm, the ulnar artery may be tied by making an incision two inches long, in a line drawn from the inner condyle to the pisiform bone. This should expose the deep fascia, which is also to be divided along the aponeurotic edge of the flexor carpi ulnaris, beneath which the artery will be found, tied only to the underlying muscular fibres by some loose cellular tissue. The needle must be passed from within outwards. An operation for tying the ulnar in its upper third has been described, but should not be practised. Either of the above operations may be employed for an aneurism lying two inches above the carpus, each for its respective vessel. But if the disease be situated lower than this, deligation of one vessel only is usually insufficient; therefore, if we operate in the forearm at all, two wounds have to be made. In my experience, however, deligation of the brachial artery, not too high, is preferable, and will cure an aneurism at the wrist, and even check hemorrhage from the palm.

Case XVI.—J., aged 7, fell, with a bottle in his hand, and divided the ulnar artery about three-quarters of an inch from the pisiform bone, on June 3, 1881. A pad and firm pressure checked the bleeding, but in five days a pulsating tumor formed in the wound; on the seventh day it burst. My house surgeon tied the ulnar artery immediately, above and below. This device answered well for another period of five days, and then pulsation recurred. Flexion failed to check the beat of the tumor. On the 13th of June, the consecutive aneurism was the size of a French olive, and beat violently in the still open wound. I found no pulse whatever in the ulnar artery, on which the aneurism was situated. Pressure on the radial, just above the wrist, entirely stopped pulsation of the tumor. Flexion had no such influence, unless a pad was placed in the

Bleeding soon recurred, and the house surgeon fastened a pad of cork on both radial and ulnar artery. This device was efficient for five days only. On a return of hemorrhage I ascertained, by careful examination, that the pressure quite commanded the pulse in both vessels, and yet the bleeding was pretty free. I tied the brachial artery, but even then, slight though quite unimportant oozing continued for thirty-six hours.

[1] There are three nerves on this aspect of the forearm. As a mnemonic, I may say that each artery lies between the median and the nerve of its own name.

bend of the elbow. This device was adopted. During the night the aneurism burst, a good deal of blood being lost before discovery of the accident. Mr. Taylor tied the brachial artery about the middle, with the thickest form of catgut which is made antiseptic.

15th. Some pulse in radial and ulnar arteries, which towards evening became strong.

17th. Pulse of both wrists alike. Flexion of elbow again resorted to.

20th. I had directed Mr. Taylor, if bleeding recurred, to send for me; accordingly, on this date, I was summoned. Hemorrhage had set in, both from the accidental and from the operation wound. It was temporarily restrained by an Esmarch cord. On examining the wound, I found, lying on the artery, the knot of a catgut ligature—the loop which ought to have been surrounding the vessel had entirely disappeared. There was an opening in the vascular coats running about one-third around the tube. I tied above and below this opening with an ox aorta ligature, and cut the ends short.[1] After this no bad symptom occurred, and in a fortnight the lad was convalescent, playing about the ward. Some slight pulsation in the radial, at the wrist, was detected on the 9th of July; it slowly increased, but was not strong when the patient left the hospital on the 12th.

*Ligation of the Brachial Artery at the Elbow.*—To tie the brachial artery at the bend of the elbow is very easy; taking the biceps tendon for his guide, the operator makes along its inner edge an incision about $1\frac{1}{2}$ inches long, and slipping a director beneath the fascia of the same name, slits it up; he will thus expose the artery, lying between the tendon and the median nerve; the needle should be slipped in between the nerve and artery. It is not always possible to avoid the median-basilic vein, even although it be visible; if it be divided, it should be tied at once. This operation is required in cases of arterio-venous aneurism at the bend of the elbow, but should not be employed for aneurisms lower down, since the wound is likely to terminate in suppuration, and in burrowing of pus along the bicipital tendon into deep parts.

Brachial Aneurism.—The brachial artery sometimes develops an aneurism at or near the bend of the elbow, as the result of a wound, but rarely spontaneously. The disease may be cured by using the Esmarch bandage, or by indirect pressure on the vessel above; but both procedures, especially if complete occlusion is aimed at, are very painful. In a few cases the tendency to spontaneous cure is so great that an occasional application of digital pressure, either by the patient himself or by assistants, will have all the desired effect. If this do not soon follow, or promise to follow, it is better not to persevere too long, as continued pressure over the median nerve becomes unbearable, and may leave the limb for months in a painful and rather useless condition.

*Ligation of Brachial Artery.*—The brachial artery may be easily reached in any part of its course—lying inside the biceps in the lower two thirds; in its upper third, inside the coraco-brachialis muscle. If the operator be accorded by the disease liberty to choose the spot at which he will tie the vessel, a point a little below the middle of the arm is the best. The incision, which at this point need not be more than two inches long, is made to follow the inner margin of the biceps, and then, either on the director or otherwise, the fascia of the arm is slit up to the same extent; this exposes the median nerve, which covers the artery, and which may be drawn to either side, preferably to the inner, since the basilic vein lies on that side, and both nerve

[1] This operation, seeing that the wound had been exposed before I arrived, was not done under the spray; although the parts were washed out with a five per cent. solution of carbolic acid, suppuration, not excessive, took place; but nothing more was ever seen of the ligatures.

and vein are thus avoided, while by passing the aneurism needle from that aspect, the veins which surround the vessel are easily separated with the end of the instrument. I would point out that the edge of the biceps should be the point aimed at—even though the artery may be felt beating a little further out—because by cutting on the edge of the muscle, the basilic vein is avoided. To make the more sure of the position, the upper arm should not rest against anything,[1] but should be held or supported by the forearm; it should be kept at more than a right angle to the trunk, with the elbow straight. If these precautions are observed, there is no difficulty in the operation.

Let it, however, be remembered that high division is not very unusual; when it occurs it is safe to tie both the branches, since recurrence of pulsation and relapse would most likely follow deligation of one only. The operator must not forget two points with regard to the median nerve; the one, that the artery sometimes lies over it, and would be endangered by over-bold use of the knife; the other, that the nerve, even when in its normal place, beats so strongly with a pulse communicated by the vessel, that it may by the inexperienced be tied in mistake.

*Ligation of Axillary Artery.*—By throwing the arm well up, in a line with the trunk, the axillary artery becomes accessible in a considerable part of its length, and may be successfully ligated almost as high as the head of the humerus; indeed, I have tied the vessel here for troubles other than those in question. For aneurism it is not desirable to operate high up on the axillary artery, and the arm, under these circumstances, may be placed at right angles with the trunk. In the last third of its course, the vessel is easily reached by making an incision in the humeral aspect of the axilla, parallel to the border of the pectoralis and a wide finger's breadth from it; this should reach, but not divide, the fascia forming the floor of the space, which may be lifted on the forceps, incised with the blade held flat-wise, and then split up on the director. Close beneath the fascia lies the axillary vein, which should be caught with a blunt hook, and drawn to the back of the wound. Lying amid loose cellular tissue are the nerves, which partly conceal the artery; upon it and on its outer side are the median, crossing it very obliquely, the ulnar, and the internal cutaneous; the two latter may be taken up and placed in charge of the hook which is already holding the vein, while the median is pressed by a retractor against the coraco-brachialis muscle. Then the needle must be passed, keeping it close to the artery so as to avoid the musculo-spiral nerve, which lies just beneath. This operation is adapted for aneurisms above the middle of the arm.

Deligation of the brachial, or of the lower part of the axillary artery, for aneurism, is so very generally successful, and is so slight an operation, that but a small number of cases are published. Moreover, since aneurisms of the arm are not very common, the operation is rarely required. I find but ten cases recorded: in all the disease was cured; in one, secondary hemorrhage was easily controlled by a pad; and in one a high division of the artery slightly embarrassed the surgeon, who, after tying one vessel, found that the aneurism still pulsated, whereupon he sought and ligatured the other branch.

In hospital records for the last ten years, I find but six cases, all of which were successful; also, by a strange coincidence, six other aneurisms of the brachial, four of which were cured by tourniquet pressure, and two by the use of the Esmarch bandage and cord.

The axillary artery has been ligatured higher up, but I would point out that to tie this vessel above the pectoralis minor, for axillary aneurism, appears

[1] When the back of the arm rests on the table, the triceps is pushed forward, and even the biceps may be somewhat displaced; hence a certain difficulty in finding the artery.

entirely inadmissible. If the disease be so situated as to throw the clavicle upward, and thus to cover the third part of the subclavian, the tract of vessel above the smaller pectoral is not likely to be unaffected. Hence it is better to aim at the artery higher up, and the operation for tying the last part of the subclavian leaves the surgeon free to go still higher, namely, to the second part, if it be necessary.[1]

For wound or rupture of the vessel, such an operation may perhaps be undertaken, though the old operation, as modified and practised by Mr. Syme, would in most cases be preferable (see p. 432). The operation may be performed in one of three methods: that of Chamberlaine, that of Roux, and that of Guthrie.

(1) Chamberlaine's operation may be thus described: An incision, beginning about two and a half inches from the inner end of the clavicle, is to run along its lower margin to the deltoid tubercle. The muscular fibres of the pectoralis major, and a few from the inner part of the deltoid, are thus exposed, and, just beneath the bone, the small triangular gap which here separates the two muscles; running into this interval the cephalic vein is seen, together with certain branches of the acromio-thoracic artery. The loose, but rather strong fascia which fills this gap may be pinched up with forceps on the inner side of the above named vein, and close to the edge of the pectoralis. A little notch having been made, without letting the forceps lose their grip, the surgeon insinuates a director under the pectoralis, and quite close to the clavicle; upon this the muscle is divided for the requisite distance. Probably at this stage one or more arteries will require tying. The next step is the very delicate one of opening the costo-coracoid membrane without dividing the axillary vein; in some subjects this fascia may be torn with the finger, but in others it is more tough, and any great amount of force might rend the vessel; if it be necessary to use the knife, the safest course is to look for the cephalic vein, and to divide the membrane just in the angle between it and the inner edge of the smaller pectoral. The artery may now be seen, but it lies deep, crossed at its upper part by the cephalic vein, and having the axillary vein on its inner, and the brachial nerves chiefly on its outer side; the needle must be passed from within outwards, and kept very close to the artery.

(2) Roux is said[2] to have tied this part of the axillary artery through the delto-pectoral interval, without division of muscle; the operation is feasible, and I have often for the sake of practice done it on the dead subject; but it would be dangerous, and is not to be recommended.

(3) In these methods of operating, only a limited part of the vessel is exposed, and if, in a case of rupture or wound, it were desirable to see more of the artery, this could only be effected by dividing the pectoralis minor, a procedure which, considering that the larger muscle would have been already in part cut through, would produce much mutilation. Hence it may in some cases be well to follow Mr. Guthrie's plan. It is, however, one not devoid of danger, and it also inflicts considerable injury upon neighboring parts; but Mr. Guthrie (as witness his proposed method for tying the posterior tibial) appears to have had a strong partiality for making large wounds. He advises an incision from the edge of the axilla to just below the acromion, and division of the large pectoral in the same direction; this of course exposes all the parts in the axilla, and if, as he advises, the lesser pectoral be also severed, the vessel may be tied in any part of its course. Great caution to avoid the axillary vein would be required. All these operations must almost inevitably give rise to

[1] I have tied the third part of the subclavian when the clavicle was raised as high as it well could be, with, it is true, certain difficulties which might have been avoided had I at that time possessed the needle depicted at p. 476.

[2] Quarante Années, etc., t. ii. p. 133.

much trouble about the axilla, and generally to widespread suppuration. The cases in which they are justifiable must be very few.

Axillary Aneurism.—This is frequently due to traumatism—even the sacculated variety is in general a sequela of over-exertion, or of attempts to reduce dislocation (which also occasionally rupture all the coats of the vessel)—but it is also sometimes spontaneous. The loose structure of the surrounding tissue causes the tumor to grow rapidly to a large, even to a very large, size. When situated high in the vessel, considerable elevation of the shoulder is caused by the mechanical filling of the axillary space.[1] Partly in consequence of the loose character of the surrounding tissue, partly from proximity of the heart, this form of aneurism runs its course rapidly. Its natural termination is rupture into the axillary cavity, causing enormous swelling and opening outwards by a slough of the skin; or it may spread along the vessel upwards to become a subclavio-axillary aneurism, and then to burst into the areolar tissue of the neck, or into the pleura. These dangers, and the rapidity of their advent, render energetic treatment imperative.

*Diet and Rest.*—This mode of treatment is unsatisfactory. Some very small number of cases may have been benefited by it, but I find no record of any having been thus cured.

*Manipulation* has not been successful in this form of aneurism; but it may be attempted if the tumor involve also the subclavian, and especially if it be of the left side. A clot, if it were detached from the upper part, might become impacted below. The treatment belongs eminently to that sort which might be called, if the expression were allowable, "hit or miss" (see p. 419).

*Proximal pressure*, that is to say, compression of the third part of the subclavian on the first rib, may occasionally succeed, but is very much more likely to fail. Both Mr. Holmes and Mr. Erichsen seem to have persuaded themselves[2] that compression of this vessel is not difficult. My own experience is, that in cases of large axillary aneurism raising the shoulder, compression of the subclavian is impossible, save for a few seconds. Syme, in order to effect this object, had to divide the skin and cervical fascia. In Poland's, and in other cases, an abnormally high course of the vessel permitted such pressure, but these favorable circumstances must, as Mr. Poland himself pointed out,[3] be very exceptional. Mr. Holmes speaks of the benefits to be expected from pressure with much more confidence than I can. He is able to cite 5 cases of cure—by Turet, Vanzetti, Cooper Forster, Peatson, and Rizzoli. The third of these was effected in two sittings by the rapid method, with the aid of an anæsthetic, under circumstances unlikely to recur. The treatment in Peatson's case occupied three months; in Rizzoli's, apparently, somewhat longer.

Nevertheless, unless the position of the clavicle render compression of the subclavian artery evidently impossible, it is the surgeon's duty to make reasonable, but not exaggerated efforts to effect a cure by such means. Unaided fingers can rarely be trusted, but a Cole's compressor will bestow additional power. This is an instrument shaped like an office seal; it has a round, or, if preferred, a pistol-shaped handle, whence projects a shank or staff, and at the

[1] Mr. Spence promulgated the idea that this lifting of the shoulder might also be due to neuro-muscular phenomena, to irritation by the tumor on the nerves of the plexus, producing muscular contraction. He seems to have momentarily lost sight of the fact that the elevators of the shoulder, the trapezius and serratus magnus being respectively supplied by the spinal accessory and posterior thoracic nerve, both originating high above the clavicle, are withdrawn from such influence.

[2] System of Surgery, vol. iii. p. 555, and Science and Art of Surgery, vol. ii. p. 120.

[3] Guy's Hospital Reports, 1871.

other end an oval pad. The shank, which is cylindrical, consists of two tubes, the one sliding within the other; they are kept from colliding by insertion within the tube of a strong spiral spring; the arrangement mitigating the rigidity and harshness of pressure, renders it somewhat more bearable. The compressor must extend beyond the patient's head, so that when he places the pad of the instrument on the proper spot, and leans a little forward, some of his bodily weight may impinge upon the vessel. The use of an anæsthetic will be very generally desirable, for proximity of large nerve trunks renders the treatment excessively painful. All the more, therefore, because the patient is unconscious, must the surgeon be cautious; injury to the vessel—eschar—even suppuration produced at this place—would be most detrimental, since the region available for this, and in case of its failure for any other method of treatment, is very small.

Although few cases of attempts to cure axillary aneurism by pressure have been recorded, I am aware of its having been frequently attempted. Some statistics have been already given: I find that among hospital cases, in the last ten years, five only are recorded as having been thus treated; of these, one (Cooper Forster) was successful, and one other doubtfully so; in one, the arm was paralyzed, and remained useless when seen many months afterwards.

*Distal and direct pressure* have not proved of any avail in the treatment of axillary aneurism. *Galvano-puncture*, or the injection of the *perchloride of iron*, might be tried in desperate cases, that is, where circumstances forbade the use of the ligature.

*Ligation of Third Part of Subclavian Artery.*—The subclavian artery in its third part is, in many cases, very easy to tie, and that with a very slight loss of blood—less indeed than may follow a tooth extraction; in other cases, although the vessel may be reached with facility, it is difficult to get a ligature around it. The method whereby this ease and bloodlessness may be attained is as follows: The patient should be placed on his back, with his shoulders somewhat raised, his head thrown a little back, and his arm separated at about a half right angle from his side. The surgeon places himself between the trunk and the arm, and notes well the place where the sterno-mastoid arises from the clavicle, and the somewhat variable position of the external jugular vein; then, placing his left hand on the larger pectoral, he draws down the integuments, and passes his knife along the clavicle, from an inch outside its sternal end to the insertion of the trapezius.[1] The skin is now to be relaxed, when the line of incision rises above the clavicle. The external jugular vein generally lies near the inner corner of this wound, and may be guarded from danger by holding it with a retractor against the outer edge of the sterno-mastoid muscle. Should it be further outward, the best and safest course is to free it from the fascia, tie it in two places, and divide it between the ligatures.[2] The incision is now to be placed so that its lower margin lies just below the upper border of the clavicle, along which the knife is to be drawn as one draws a pencil along a ruler, taking care to sink the instrument to only half the depth of the bone. By this means the strong layer of fascia that runs from the sterno-mastoid to the trapezius is divided. After this—and herein lies the difference in my teaching from that of other operators—no further use of the knife need be made: the structures which lie between the fibrous covering of the posterior triangle and the vessel are so loose and fragile, that they may, as a very general rule, be torn and pushed

[1] A branch from the cephalic vein may run across the line of incision, and be divided; it is sometimes rather large, and bleeds pretty smartly—if so, it should be tied.

[2] It is not so much the bleeding from this vein that is to be feared, as the possibility that air may enter the lower orifice if it be unwittingly cut across.

aside with the finger; no dissection, such as is prescribed in works on operative surgery, ought to be practised, for it is that which renders the operation difficult, causing hemorrhage, filling the cup-like wound with blood, and obscuring the further steps. The operator, placing his fore-finger in the inner angle of the wound, feels the softer, yielding structures of the side of the neck; further inward, the hard, firm line of the spinal transverse processes covered by the scalenus anticus; and, running outward from the edge of this muscle, the ridges of the brachial nerves, and perhaps the omo-hyoid; still letting his finger course downward along the outer border of the scalenus anticus, he will find its progress stopped by the first rib; when he comes to this point, the artery will be felt beating just behind his finger. If now the head be turned to the opposite shoulder, and the arm of the side under operation be drawn down, the fascia of these parts is rendered tense enough to be easily torn, and with the finger nail, guided by a good sense of touch, the upper and lower margin of the vessel may be cleared. If there be any difficulty, a piece of the fascia may be pinched up in forceps, the absence in it of any vein carefully verified, and a very small rift in it made—from which the tear may be extended with the finger.

Now unless the shoulder be raised by the aneurism, this operation may be performed in a few minutes with the utmost ease; but if that part is pushed upward, very considerable difficulty is produced, for this position may be so embarrassing that the surgeon can hardly orient himself.[1] Furthermore, the clavicle so covers the artery that, even though the aneurism needle may pass beneath the vessel, its handle cannot be depressed; the eye will not go far enough to let the ligature be seized. It is for this object that I devised the needle with the tumbler-end, depicted at p. 476. Unfortunately, I have had no case requiring its use since then; but I have often tried it on the dead subject, while an assistant kept the shoulder well raised, and have found it to answer all expectations.

The above operation is not applicable to *subclavio-axillary aneurism*, but in such cases the *second part* of the subclavian artery is rarely diseased. This fact appears to me to have been somewhat neglected by operators; for in such an event, rather than tie a dilated artery, it will be better to take up the vessel a little further inward, namely, where it lies between the scaleni. Another circumstance which may render this operation preferable to the one just described, may be such a lifting of the clavicle that the third portion of the vessel is inaccessible. The artery lies highest while between the muscles; and the clavicle, raised by an axillary tumor, is less elevated at its proximal part.

*Ligation of Second Portion of Subclavian Artery.*—To place a ligature on this part of the vessel, a slight modification of the procedure already described is necessary. The skin incision must extend a little more inwards, and the external jugular vein, unless it lie unusually far out, should be tied and divided; the outer fibres of the sterno-mastoid, together with the strong fascia behind it, must be severed. The loose areolar structure overlying the anterior scalene muscle is easily disposed of, and the phrenic nerve as it crosses that muscle very obliquely, must be brought into view. The artery, emerging from between the two scaleni, is now seen; between it and the anterior muscle a curved director is to be passed, and the outer fibres of the latter divided, when the safety of the vessel itself and of its branches has been verified,[2] and when the

[1] In a case of this sort, on which I operated, my finger sank almost its full length directly downward. I had to verify its position once or twice, the great depth haunting me with a fear that my finger had entered the chest.

[2] Usually, the only branch given off from this portion of the artery is the superior inter-costal, which is not in the way; but the supra-scapular branch from the thyroid axis is often low enough to be endangered, unless its absence from in front of the part to be incised has been ascertained.

phrenic nerve has been drawn inward or protected. The position of the pleura must also be remembered: its safety can be secured by passing the director, and using the knife, rather on the upper aspect of the artery. The support of muscular fibres causes this part of the vessel frequently to escape dilatation, which may affect both the first and the third part; the condition might be called an hour-glass aneurism. Or disease creeping up along the vessel from the axillary may involve the third part of the subclavian artery, yet terminate sharply and suddenly at the border of the scalenus. In either case, ligation in this situation is far more likely to prove successful than at the third part of the artery.

If the *first part* of the subclavian be also dilated, it may be advisable to extend the incision a little further inward (unless the parts can be drawn in that direction), and to tie also the vertebral; great care must be used to avoid the phrenic nerve. We shall see presently that the very large inosculations at the base of the brain may render it dangerous to keep this vessel pervious.

The statistics of tying the subclavian for axillary aneurism, which will be given immediately, are not very favorable. I am sure that the more modern forms of ligature will change the ratio of cures very considerably. However this may be, it was no doubt these unfavorable results that led Mr. Syme to advise recurrence to the old operation.[1] The case on which he founded his recommendation was one of ruptured artery, and in that instance his procedure was doubtless right, for in such cases the Hunterian method is not likely to prove efficacious.[2] But no one who reads that surgeon's description of his operation will, I think, be tempted to follow his example in cases of sacculated aneurism, unless the position of the shoulder renders it evidently impossible to reach the subclavian artery. Moreover, in his case, the rupture of the vessel must have been at the lower part of the axillary, since Mr. Syme reached the distal end with ease, and was able to tie the proximal end half an inch *above its orifice;* it is questionable whether a sacculated aneurism of the first part of the axillary could thus be treated, and, even if it were found possible, the mortality would probably be very great.[3]

Axillary aneurism is a very serious disease, its treatment often proving ineffectual. The failure arises from several causes, viz., (1) the numerous and free anastomoses between the axillary artery and the subclavian; (2) the very loose character of the surrounding structures, causing rapid growth and facile rupture, so that the aneurism, while undergoing treatment, frequently becomes diffused; (3) the fact that the disease, though its symptoms may indicate simply axillary aneurism, often extends above the rib, so that the ligature is applied to a vessel already thinned and dilated—in other words, to an upward prolongation of the sac.

Of statistics concerning this operation, we have a singular abundance in the tables of Norris,[4] Koch,[5] and Poland,[6] the latter, however, chiefly concerning subclavian aneurism, as English and American surgeons define it. Some ambiguity must here arise, since, in different countries, the arbitrary line of demarcation between the subclavian and axillary arteries varies considerably. For English-speaking anatomists, the latter vessel begins at the lower border of the first rib, and for Germans, at the lower border of the pectoralis minor;

[1] Med.-Chir. Trans., vol. xliii. p. 137.

[2] In a postscript, he mentions having carried out the same method for a sacculated aneurism, the patient returning home in a month.

[3] Mr. Syme's proposal to treat inguinal aneurisms and carotid aneurisms on a similar plan certainly cannot be entertained. Treatment by distal ligature will be considered hereafter.

[4] Contributions to Practical Surgery, p. 220.

[5] Archiv für klinische Chirurgie, Bd. x. S. 195.

[6] Guy's Hospital Reports, 1870, 1871, 1872.

while the French take as their boundary "the clavicle," a somewhat movable and uncertain line,[1] and the Italians go still higher, making the subclavian cease at the outer border of the scalenus anticus. This ambiguity I have done my best to eliminate.

Norris gives of deligations for axillary and subclavio-axillary aneurism (I omit operations for other conditions), 60 cases, of which 27 proved fatal—a death-rate of 45 per cent. Koch's tables record 79 cases in which the subclavian artery was ligatured for axillary aneurism,[2] of which 27 were fatal—a mortality of 34.3 per cent. Since the publication of Koch's paper, which includes, I believe, all the cases noted by Norris, I gather from journals only 11 instances of this deligation, of which no less than 5 died, a mortality of 45.45 per cent. Thus:—

| | Cases. | Deaths. | Mortality, per cent. |
|---|---|---|---|
| Norris | 60 | 27 | 45. |
| Koch | 79 | 27 | 34.1 |
| Since 1869 | 11 | 5 | 45.45 |

If we put together the two last gatherings,[3] we have:—

| Cases. | Deaths. | Mortality, per cent. |
|---|---|---|
| 90 | 32 | 35.5 |

The causes of death in the 32 cases are thus distributed:[4]—

| | |
|---|---|
| Secondary hemorrhage from site of ligature | 10 |
| Suppuration or gangrene of the sac, usually with bleeding | 10[5] |
| Rupture of aneurism | 1 |
| Gangrene | 1 |
| Exhaustion | 3 |
| Pyæmia | 2 |
| Pulmonary or pleural complications | 3 |
| Drunkenness, when nearly well | 1 |
| Not stated | 1 |

These numbers seem to me to require still further examination—carrying division still further by separating the aneurisms which were purely axillary from those that encroached on the subclavian—because the larger number of cases which proved fatal from hemorrhage at the site of deligation, and some in which the bleeding came from the sac, were of the latter category; and because, as we might expect, tying the third part of the subclavian when that division of the vessel participates in the disease, is not likely to prove a very successful procedure. Taken, then, in this wise, the statistics stand thus:—

| | Cases. | Recoveries. | Deaths. | Mortality, per cent. |
|---|---|---|---|---|
| Axillary | 61 | 46 | 15 | 24.6 |
| Subclavio-axillary | 29 | 12 | 17 | 58.6 |

We may conclude, therefore, that to tie the third part of the subclavian artery, when an aneurism encroaches upward beyond the border of the first rib,

[1] Velpeau (Anatomie des Régions, tome i. p. 239) speaks of the lower end of the subclavian as lying on the first digitation of the serratus magnus.

[2] Among these I include cases of what he terms infra-clavicular subclavian aneurism. My numbers vary from those quoted by Poland, probably from some difference in the mode of analyzing the records.

[3] Norris's and Koch's figures, since they include the same cases, cannot be added together.

[4] Since these statistics were compiled, the essays of my friend, Dr. Wyeth, have been sent to me by their author. I find, at page 239, that he gives 75 cases of axillary aneurism as treated by deligation of the third part of the subclavian; of these 28 terminated fatally, a mortality of 37 per cent.—a conclusion so similar to my own that I have thought it best not to alter my modifications of, and additions to, the figures of Norris, Koch, and Poland, but to leave the two results as corroborative of each other's accuracy.

[5] Two of these cases had been treated with ergotine injections; the sac was severely inflamed previous to operation.

is a very dangerous though, occasionally, an unavoidable procedure; but that deligation of the third part of the subclavian, when the aneurism can be diagnosed as purely axillary, is comparatively safe, since more than 3 out of 4 thus treated recover.

The cases of axillary aneurism[1] treated in the six London hospitals, the records of which I have utilized, have been 17. Of these, only 4 came to ligature. The smallness of the number is due, I believe, to the effect of Mr. Poland's paper, which brought the operation into a disrepute which, as far at least as purely axillary aneurism is concerned, is undeserved. Of the 4 patients thus treated, 1 died of erysipelas when all but well, and when the tumor was nearly solid. The results of the different forms of treatment employed are here given:—

| | |
|---|---|
| 5, pressure | 3 failures, 1 death, 1 recovery. |
| 3, amputation | 3 deaths. |
| 1, Valsalva's method and aconite | no benefit. |
| 3, expectant measures, or operation declined | 3 deaths. |
| 4, ligature | 1 death, 3 recoveries. |
| 1, old operation | recovery. |

## Aneurisms of the Head and Neck.

Having now traced aneurismal disease of the upper limb to the trunk, we will leave the vessels hitherto dealt with, and will examine the malady as it affects the carotid and its branches.

Aneurism of a *cervical branch* of the carotid may occur, but rather as a surgical curiosity than as a malady requiring notice, save in works especially dedicated to such subjects. In practice, the disease manifests itself either as affecting the main vessel itself (common, external, or, very much more rarely, internal carotid), or as intra-cranial or orbital aneurism.

Intracranial Aneurism interests the surgeon but little; it usually manifests itself by death from apoplexy after a certain duration of pressure symptoms, or without such prodromata, and in the post-mortem room by a large effusion of blood in or on the brain, the effusion being traceable to the rupture of some dilated vessel. In a few cases, peculiar signs of localized pressure on the brain, especially if accompanied by complaints of loud whirring or rasping sounds, may lead the physician to suspect the existence of such an aneurism, and this diagnosis is very much strengthened when he can himself hear, by a stethoscope applied to the head, or by the otoscope, some such sound, synchronous with the pulse. It must be remembered that the arteries of the brain are especially those most liable to be the seat of syphilitic degenerations (p. 388), and yet the fact that a patient with symptoms of intra-cranial pressure is syphilitic, may point to the existence of a tumor, gummous or otherwise, as well as to vascular disease. If an aneurism be diagnosed, a certain localization may be sought by finding at which part the bruit is loudest, and by pressure on each carotid alternately, and then on both. Cessation of the noise, on occlusion of one only, might lead to treatment by pressure; but since the vessels which spring from the four channels carrying blood into the skull intercommunicate very freely, any treatment which closes but one of these branches will be likely to influence the condition of the vessels in but a very transitory manner.

[1] Here I have not been able to draw the above distinction.

Orbital Aneurism, or rather *pulsating tumor of the orbit*, presents many problems of great interest and difficulty, for it is by no means to be supposed that the pulsation arises of necessity from diseases of the ophthalmic artery, nor, indeed, that it is in the orbit at all. The maladies which may produce a pulsatile tumor in this situation may be thus classified:—

| | | |
|---|---|---|
| Within the orbit. | Disease not of vessels.[1] | Erectile tumor.<br>Myeloid sarcoma, or encephaloid.<br>Meningocele at sphenoidal fissure or at a suture. |
| | Venous or capillary disease. | Thrombosis of ophthalmic vein.[2]<br>Varicose condition of ophthalmic vein.[2]<br>Aneurism (cirsoid) by anastomosis. |
| | Arterial disease. | Circumscribed aneurism of the carotid in the cavernous sinus.<br>Diffused aneurism.<br>Arterio-venous aneurism. |
| Within the skull. | Venous morbid condition. | Thrombosis of cavernous sinus.[3] |
| | Arterial disease. | Circumscribed aneurism of internal carotid in cavernous sinus.<br>Diffused aneurism.<br>Arterio-venous aneurism. |

The diagnosis between the growths first mentioned and vascular disease must be gathered from the general directions given at p. 396; but in this particular situation unusual difficulty is caused by the confined space in which the disease lies, and by the inaccessibility to touch thereby produced. Meningocele of the orbit is very rare, and could hardly occur save in infants, or at least when taking its origin in infancy. The nature of M. Guersant's case, which was brought before the Surgical Society of Paris,[4] was recognized by none of those who examined it, and treatment with a seton proved rapidly fatal. The presence of a distinct pulsatile tumor, and its being readily emptied by pressure, are the misleading points; but the absence of bruit which can be detected by the surgeon, and of loud noises heard by the patient, should lead to a suspicion of the non-aneurismal nature of the case. If the tumor, not compressing the veins, caused no swollen condition of those vessels, and no marked congestion, the diagnosis would rest between the disease in question and the two other tumors not due to vascular changes; but if such venous disturbance were produced, greater diagnostic difficulties would arise. One of the cases reported was traumatic, the injury occurring at one year of age. The surgeon (Oettingen) examined the case in the thirteenth year of life.

The other divisions of the table relate to various forms of vascular disease, and it will, for the present, be better to consider their symptoms altogether, without further reference just now to their anatomy than the remark that both venous and arterial dilatation are capable of giving rise to a pulsatile tumor of the orbit, and to protrusion of the eyeball (which may itself also pulsate), and this whether the morbid state be located within that cavity or behind it, viz., in the cavernous sinus and surrounding structures. The symp-

[1] To this might have been added certain cases of pulsation which, no cause having been found after death, M. Collard (Gazette Méd. 1866, p. 631) ascribed to a morbid condition of the vaso-motor nerves given off by the lenticular ganglion. Without wishing to deny the possible truth of this causation, I prefer to exclude it from my table as being at present merely speculative, and resting on no fact in morbid anatomy.

[2] Both of these may result from disease behind the orbit.

[3] Solid tumors compressing the cavernous sinus might have the same effect, but in point of fact such have not been found.

[4] Guersant, Maladies des Enfants, p. 246.

toms are these, taken in the order of their usual occurrence: Pains about the orbit, temple, and brow; noise in the head; swelling of eyelids and conjunctiva, with considerable congestion, and, perhaps, a varicose condition of both the palpebral and ocular portions of that membrane; pulsation of the eyeball (sometimes absent); proptosis or exophthalmos, rapidly increasing; more or less rapid disorganization of the globe; formation of a distinct tumor between the eye and margin of the orbit, generally about the junction of the inner and middle thirds of the superciliary arch. In most cases the noise may be heard on auscultation, about the forehead and temporal fossa, or by the otoscope. The exophthalmos has been, in some cases, extreme, the eyeball being quite extruded—in one case it was reported as lying on the cheek below the malar bone. The impairment of vision and the paralysis of orbital muscles is not in strict ratio with the amount of protrusion, being earlier and more marked in certain forms of the disease than in others.

More than half of the recorded cases, viz., 41, have been traumatic. Of these, 31 were in males, 10 in females; 19 were due to falls, 13 to blows about the head, 1 to a blow on the nape of the neck, 7 to wounds (1 charge of shot, 1 splinter of glass, 5 stabs with stick or umbrella). The other cases were idiopathic, namely, 33; of these, 9 only occurred in males, 24 in females. But in nearly all of these, also, the disease commenced suddenly—sometimes after an effort, during the progress of labor, or after a violent fit of coughing—while in other cases the sudden attack began during sleep, without apparent immediate cause. The first advent of the malady has been in such cases marked by a sound, as of a snap, a pistol shot, or the crack of a whip, usually preceded or accompanied by a sense of something having given way within the head.[1] Suggestive of embolism as a possible cause, is the fact that of the idiopathic cases among women, one-third have occurred during pregnancy.

Of the 76 cases on record (three have occurred since Mr. Rivington's paper was published), opportunity for post-mortem examination occurred in only 13. The results were:—

| | | | |
|---|---|---|---|
| In | 1 | case, | circumscribed aneurism of the ophthalmic arteries within the orbit. |
| " | 1 | " | "  "  "  "  artery at origin from carotid. |
| " | 3 | " | rupture of internal carotid in cavernous sinus. |
| " | 1 | " | atheroma with dilatation of carotid in cavernous sinus. |
| " | 3 | " | arterio-venous aneurism in cavernous sinus (traumatic). |
| " | 2 | " | plugging of cavernous sinus and ophthalmic vein. |
| " | 2 | " | obstruction of blood from orbit in cavernous sinus. |

Though we must not accept this table as absolutely representing all the morbid conditions which may produce pulsating tumors, nor their relative frequency—since the more curable forms would escape post-mortem examination—yet we must, to a certain extent, accept its guidance. Now, it is remarkable that we find no case of aneurism by anastomosis, only one case in which the disease was in the orbit itself, and only two of aneurism of the ophthalmic artery. Nevertheless, it is probable that this last condition has occurred more frequently, as in Van Buren's[2] and Curling's cases.[3]

The summing up of all the evidence is, that pulsatile tumor of the orbit is usually due to some condition behind that cavity, and as often to venous as to arterial disease; but it appears to me impossible to agree with Mr.

[1] Mr. Rivington's excellent and interesting paper (Medico-Chirurgical Transactions, vol. lviii. p. 183) enters minutely into the statistics of this malady, with regard to age, sex, side of affection, etc. For further detail I must refer to that exhaustive paper.

[2] See paper by Dr. Noyes, New York Medical Journal, 1869.

[3] Medico-Chirurgical Transactions, vol. xxxviii. p. 109.

Erichsen's[1] and M. Collard's view, that the condition may be produced by no disease at all. So obscure, however, are some of the symptoms, that it is at present impossible to fix absolutely the differential diagnosis of certain of the lesions, save by means of exclusion, observation of signs, and inference; yet it is most important, in view of treatment, to be able to distinguish one form of malady—viz., the arterial—from the others.

*Cirsoid aneurism of the orbit* is, to say the least, a very rare disease.[2] Unless slowly supervening upon a badly-healed wound—and that would be a pathological curiosity—it would be the sequela of a congenital condition, and some signs of angeiomatous arteries—not merely varicose veins—would be found. It never could arise suddenly, with a snap or crack, nor follow closely upon some traumatism; nor would the noise be great, but rather a low-breathing murmur than a rasping or sawing sound.

*Circumscribed aneurism within the orbit* may sometimes exhibit a distinct tumor below the upper eyelid, protruding the conjunctiva, in which case its consistence and mode of pulsation may aid diagnosis; but chiefly must we be guided by its bruit or susurrus. Its clear, intermitting sound can, in typical cases, be hardly mistaken for the pur or snarl of arterio-venous aneurism on the one hand, or for the soft sigh or hum of venous fulness, or of aneurism by anastomosis, on the other.

*Arterio-venous aneurism*, always traumatic, and usually preceded by signs of fracture at the base of the skull,[3] emits a very loud rasping sound, already described.

*Venous congestion* or *occlusion* generally comes on more slowly, and is not preceded or accompanied by any smart snap, or sound of breakage; it is marked by complete noiselessness, or very gentle murmur, and by a more compressible, softer state of the tumor, and of the pulsation. The ophthalmoscope may in some cases show particularly well-marked venous congestion, and full vortices, but the instrument is not always available, owing often to rapid changes occurring in the media. Puncture of the tumor with a fine trocar might, as Mr. Rivington suggests, reveal the venous or arterial nature of the contents. The decision as to whether the disease is in the orbit or in the sinus behind it, is frequently impossible, unless fracture of the base of the skull, or certain negative signs about the orbit, be present. Some conclusion may, perhaps, be formed from the different forms of paralysis of the ocular muscles—such symptoms as ptosis, and internal squint from paralysis of the third nerve,[4] together with slight or no impairment of vision. Again, œdema of the eyelids coming on early, and before pulsation is felt, if its advent be slow, and unmarked either by traumatism or any sudden sense of something giving way, is a sign of venous obstruction; if the heart and large vessels be not markedly diseased, the evidence is in favor of this obstruction being independent either of aneurism or of rupture of the artery in the cavernous sinus. Nevertheless, it must be confessed that many paradoxical cases occur, such as Velpeau's,[5] in which both eyes were affected, and in which compression of the right carotid stopped pulsation in the left eye, and *vice versa*, a condition which that author and Mr. Holmes have both endeavored, but without success, to explain. Ligature of the right vessel checked pulsation in both eyes for a

[1] Science and Art of Surgery, vol. ii. p. 104.

[2] Probably Dr. Frothingham's case (American Journal of the Medical Sciences, April, 1876) was of this description.

[3] Les anévrismes artério-veineux du sinus caverneux, pai M. le docteur Delens. See also Dr. Morton's paper in the American Journal of the Medical Sciences, July, 1870.

[4] The tumor in the orbit lies, when present, above and inside the eyeball, which is generally pressed outward, so that there is an appearance of external squint, with the eye looking downward; rapid loss of vision is also characteristic of disease within the orbit.

[5] Delens, op. cit.

time, but this soon recurred in the right eye, while the left was cured. Nor have we the means of diagnosing certain venous conditions of the cavernous sinus from aneurism of that part, nor from similar states in the orbit. Indeed, it is hardly to be perceived whence such means should come; if obstructed veins in that sinus produce pulsation, tumor, exophthalmos, etc., those symptoms will arise, whether the occlusion be produced by aneurism, by rupture of the artery, or by thrombosis of the vein. Hence, operative measures should not too readily be undertaken, since some patients—those of Erichsen[1] and Collard, of Berne,[2] for instance—recovered; the former nearly, the latter entirely, after merely expectant measures and regulation of diet.

*Treatment of Pulsating Orbital Tumors.*—The treatment must be guided by the conclusions formed from the symptoms just detailed. I would only point out that compression of the carotid may, in every form of the disease, annul pulsation, even though no aneurism be present; this symptom accompanies the venous turgesence due to thrombosis, the impulse being communicated by the throb of the artery.

*Expectant* and *medical treatment* is that which is best adapted to cases diagnosed as thrombosis or other affection of the veins. Ice, digitalis, sparse diet, absence of stimulus; in certain cases, iodide and bromide of potassium, with ammonia; purgatives, and if inflammatory mischief be present, means adopted to relieve that condition.

*Graduated compression* upon the globe and orbit may be useful in the same class of cases. If aneurism be present, it is injurious. Injection of ergot might be employed in cases of any of the diseases mentioned, if its situation within the orbit could be ascertained.

*Coagulating injections* likewise can only be of use if the orbit itself be the seat of disease.

*Galvano-puncture* may share the same remark, with this addition, that a strong or prolonged electric current can hardly be conducted through any portion of the head or face without danger.

For all true forms of orbital aneurism, *compression* and *ligature of the common carotid* artery are the remedies *par excellence;* but, as in other parts of the body, deligation of the vessel leading to an aneurism by anastomosis, is rarely curative. For such cases, when recognized, vessels immediately leading to the tumor, such as the facial and the temporal, have been tied, but with only slight and temporary benefit,[3] while deligation of the common carotid, after an interval, cured them easily and quickly.

The following table shows the results of the different modes of treatment employed:—

| Form of treatment. | No. of cases. | Cured. | Benefited. | Loss of vision. | Unrelieved. | Died. | Subjected to other treatment. |
|---|---|---|---|---|---|---|---|
| Expectant and medical . | 25 | 5 | 1 | 1 | 11 | 7 | |
| Direct compression . . | 10 | .. | 3 | .. | 7 | | |
| Galvano-puncture . . . | 2 | .. | .. | .. | 2 | | |
| Injection of ergot . . . | 2 | .. | .. | .. | 2 | | |
| Coagulating injection . . | 4 | 2 | .. | 1 | 1 | | |
| Compression of carotid . | 16 | 1[4] | 1 | 1 | 13 | | |
| Ligature of carotid . . . | 44 | 16 | 6 | 7 | 5 | 6[5] | 4[6] |
| Ligature of vessel in orbit | 1 | 1 | | | | | |

[1] Op. cit. [2] Gazette Medicale, 1866, p. 321. [3] Warren, loc. cit., first case.

[4] Rivington gives two idiopathic cases thus treated, as cured, but in one of these vision was lost; in the other noises in the head continued.

[5] The cause of death is not stated in one; it was secondary hemorrhage in two; pyæmia in two; cerebral disturbance in one.

[6] Three of these were cured: 1 by injection of the lactate of iron, 2 by deligation of the other carotid; 1 died after galvano-puncture.

I have not wished to alter these numbers, gathered from Mr. Rivington's paper, by the addition of the only case published since it was written. This was Von Neiden's[1] case; pressure, continued for ten weeks, failed; ligature of the carotid cured.

Relapse occurred, or threatened, on the other side, in one case; the condition was successfully treated by the administration of digitalis, local compression, and the application of ice.

Relapse on the same side occurred eight times, six of the cases being traumatic; subsidence took place in one idiopathic case, and in two of the traumatic cases. In two American cases, both carotids were tied, and in a third (Frothingham), after partial relapse, the spongy remains of the tumor were dissected out. Since relapse is most frequent in traumatic cases, it is probable that the condition arises from arterio-venous aneurism; or, perhaps, that both carotids, or one carotid and a branch from the other, communicate with the sac of an aneurism behind the orbit.

Ligature in the orbit of an artery feeding an orbital aneurism can only be employed in very exceptional circumstances. The case so treated by Mr. Lansdowne resulted from a wound of the upper eyelid, which was followed by a consecutive traumatic aneurism of the injured vessel.

Carotid Aneurism.—Carotid aneurism has been said to be more common in women than in men; but this is an error. I find in Pilz's tables, to be quoted immediately, 88 cases of this disease; of these, 55 were in men and 28 in women, the sex in 5 not being stated. The external branch is affected in 7 per cent. of the cases of carotid aneurism; the internal in about 5.75 per cent. The very large proportion of 87.25 per cent. belongs to the primitive trunk. The most usual point for the appearance of the tumor is the bifurcation, but it may also have its seat quite at the lower part of the neck, immediately above the clavicle. For reasons which will appear shortly, I prefer to divide these cases into those of *high carotid aneurism*, to be now investigated, and of *low carotid aneurism*, which can be better discussed with subclavian, innominate, and aortic aneurisms, under the category of *aneurism at the root of the neck*.

Aneurism of the carotid artery, at or near the bifurcation, lies between the trachea and the sterno-mastoid muscle, and is so easy of diagnosis that nothing on that subject need be said here;[2] but the surgeon should be aware that a certain normal increase in the size of the artery, just at its division, is, especially in women, not very unusual, and that this expansion may, as age advances, become more conspicuous, either from the loss of subcutaneous fat, frequent in elderly females, or from real enlargement, which may not, however, pass the limits dividing disease from mere peculiarity of form. Hence, a pulsating tumor at this part of the female neck should not be at once considered, still less treated, as aneurismal, more especially if it have been discovered through accident, by touch or sight, or have been merely observed by some third person, the patient experiencing no painful or obstructive symptoms. The rule, in such a case, is to carefully watch the tumor, and to measure it by compasses or other means, from day to day, or week by week. If it be stationary, and no pressure symptoms arise, surgical interference is unnecessary, or may at least be postponed.

Case XVII.—I was consulted in November, 1878, by Mrs. G., aged 62, on account of a pulsating tumor on the right side of her neck, which gave her no inconvenience, and had first been observed by her husband. There was no history of injury, and the

[1] Zeitschrift für praktisch. Medizin, No. 47.

[2] Certain points of differential diagnosis between this disease and certain cysts of the neck, are given at p. 395.

lady was in perfect health, but of late had grown considerably thinner. There was very visible pulsation on a level with the thyroid cartilage; at each systole the tumor looked nearly the size of a pigeon's egg; the pulsation, which was markedly expansile, ceased on compressing the carotid below. To the touch, a rather considerable dilatation of the artery was evident, but not as great as it appeared to sight—some of the expansion being certainly venous, probably from pressure of the dilated part of the artery on the jugular vein. I carefully measured the limits of expansile pulsation, and watched the case closely during a fortnight, and in that time found no change whatever. Relaxing my vigilance, I saw the patient then only from time to time. In February, 1879, I happened to meet at her house her younger sister, who told me that previous to her marriage, which happened just before she was twenty, my patient had been very thin, and she (the sister), with others, had often noticed a great beating on the right side of her neck, and that the spot looked then, as far as she could remember, exactly the same as it did at the time of speaking. After marriage, and until lately, the lady had been considerably stouter, and it is likely that the increased *embonpoint* overlay and concealed the pulsation.

While avoiding unnecessary interference, we are to remember that, if the tumor be increasing, no time should be uselessly lost; the growth is in this situation usually rapid; nor is there very much room to spare. Such aneurisms tend, as a very general rule, upward, yet, combined with growth in that direction, a certain downward extension may also occur. If in growing the tumor come to cover the trunk of the artery, the difficulties and dangers of treatment are enormously increased.

Many of the resources of surgery, useful in other situations, are inapplicable to carotid aneurism. Coagulating injections, and even galvano-puncture, would be dangerous in this place.[1] The parenchymatous injection of ergot might be tried by one who had faith in it; and direct pressure by means of a truss-like instrument of a horse-shoe shape—a somewhat modified Signoroni's tourniquet—might be employed if the aneurism were small and firm. But, in truth, our means of attack are almost limited to proximal pressure and ligature.

There is no doubt that indirect pressure, combined or alternated with the direct, may cure a certain class of aneurisms of the neck, as also of the orbit. The compression may be in part instrumental; thus, for instance, a Cole's compressor may be used with the hand. Mechanisms carrying movable arms (adaptations of Carte's instrument to the neck) generally disappoint both surgeon and patient. Digital compression is much more bearable, and, in truth, if a sufficient staff can be mustered, is much more easily effected. The place where the least amount of force exerts the greatest influence, is the carotid (or Chassaignac's) tubercle, as the transverse process of the sixth cervical vertebra is called. Generally, pressure on any part of the vessel produces after a time vertigo, tinnitus aurium, faintness, and a sense of sickness. This is generally attributed to disturbance of the cerebral circulation, but I believe wrongfully. It seems to me that interference by compression with the sympathetic, perhaps also with the pneumogastric nerve, is more likely to be the cause of the unpleasant sensations. After a certain number of sittings the parts become accustomed to the manipulation, and the unpleasant symptoms diminish.

Another mode of compression, that of Rouge, may be substituted for, or may alternate with, that just described; to effect this, the patient's head must be so placed to relax the sterno-mastoid muscle, on one side of which the surgeon places his thumb, on the other his finger; then insinuating them behind the muscle, he, as it were, pinches the carotid between them. The manœuvre is best and most easily carried out some distance above Chassaignac's tubercle;

[1] The gas-bubbles and tar-like fluid, described at p. 415, might act injuriously on the brain.

it fatigues the hand rapidly, but obviates the troubles which patients so often experience when the vessel is compressed against the spine. Even with the best precautions it will be impossible, while the patient is conscious, to prolong the sittings very much, or to let them follow each other rapidly. Thus, in orbital aneurism, the pressure in the three successful cases was used in one case (Gioppi) for a minute or two at a time; in another, for about five minutes; and in the third, from twenty to thirty minutes a day. In the very few cases of success in carotid aneurism, from ten to fifteen minutes' pressure was (if I read the accounts correctly) the utmost that could be borne. The rapid method is, of course, open to the surgeon; but he must remember that this method may require from one to many hours' anæsthesia; he may, during such treatment, have great difficulty in distinguishing between the causes of syncope or asphyxia that may be due either to the direct effect of the anæsthetic, to cutting off a part of the blood-supply to the brain, or to failure of the heart or lungs through pressure upon the pneumogastric and sympathetic nerves. Such pressure, while the patient is under the influence of any anæsthetic, can hardly be free from danger. Pressure is reported to have been successful in six cases; of these, three were traumatic. Of the others, I may say that one occurring in a rather lean old lady (reported as greatly benefited, but afterwards relapsed), was, to my mind, not an aneurism, but one of those not abnormal enlargements at the bifurcation already mentioned. It is quite impossible to ascertain the number of cases in which pressure has been used and failed—and a proportion or percentage of its effects is therefore unobtainable.

The proximal ligature for high carotid aneurism is the form of operation to be chosen, and, when possible, one would elect to tie the vessel shortly below its fork; but in some cases the position of the sac leaves no choice—the vessel must be taken up, if at all, lower down in the neck; the two forms of operation are termed respectively "above" and "below" the omo-hyoid. The former is the easier, and is thus performed.

*Ligation of Carotid above Omo-hyoid.*—The patient, being etherized, should have a rather thick pillow placed under the shoulders, but none under the head, which, falling back, renders the middle part of the neck prominent; the face should be slightly turned towards the unaffected side.[1] The surgeon feels about midway between the clavicle and the ear for the edge of the sterno-mastoid muscle, and makes there an incision about two and one-half inches long, so placed that its middle shall be on a level with the cricoid cartilage. This incision may go at once through the platysma and fascia, but if this latter structure be not then divided (the muscular fibres of the sterno-mastoid not being in view) the knife must be drawn down the track again. In doing this, it is well to spare any large vein (the external jugular sometimes crosses here), or to tie it, if divided, at both ends. The operator's finger will, if the fascia have been sufficiently incised, very easily turn the sterno-mastoid outward, and then will be seen the omo-hyoid, which can generally be pressed inward without using the knife; or the fascia, on its outer edge, may require some dissection. These two muscles, with the other soft parts, are now to be held respectively inward and outward. On looking into the wound, the operator sees the yellow, fat-charged fascia, one

[1] Once or twice I have found my assistants forcing the patient's chin far over to the opposite shoulder; this embarrasses, as it causes the sterno-mastoid to overlie the artery: the chin should be kept about midway between the acromion and the episternal notch of the opposite side. I may add here, that in certain aneurismal cases (aortic and innominate) the etherized patient cannot breathe while the head is thrown back; the anæsthetizer is obliged to insist on bending it forward, and the operator has to get at the vessel under very trying circumstances, since in that posture it lies much deeper, and the ramus of the jaw is terribly in the way.

part of which covers the vessel (sheath), and, running obliquely through it, a quantity of veins, which should be avoided[1] by placing the finger in the depth of the wound, and finding the pulse of the carotid at a place free from venous complication. Here a bit of the fascial sheath should be pinched up on the front, inner aspect of the vessel, a little hole made, the director passed in, the safety of the descendens noni nerve verified, the sheath slit far enough to let the naked artery be seen, and the needle passed from without inward.

A few words about the nerves. The descendens noni lies at this place, on the outer aspect of the sheath, and will rarely be endangered if that structure be opened as above described; but it is well to see that it is out of the line taken by the director; if its absence there be verified, it need not be hunted up elsewhere. The pneumogastric nerve lies in the interval between the artery and vein in the back part of, but not loose in, the sheath; each of the vessels, as well as the nerve, has a compartment, strongly walled, to itself, while the sympathetic, behind the sheath, is also separated by a thick fascia from the vessels. If these anatomical positions be maintained, both nerves are safe.[2] Young operators are sometimes made anxious and embarrassed by unnecessary cautions, yet sometimes the parts do not quite maintain their proper positions; hence it is well, before tightening the ligature, to see that it includes the artery only.

*Ligation of Carotid below Omo-hyoid.*—The low operation also requires an incision about two and a half or three inches in length, along the inner margin of the sterno-mastoid; it may extend from just below the level of the cricoid cartilage to an inch or half an inch above the sterno-clavicular joint.[3] The fascia may be freely divided and the muscle turned outward; judging from my own experience, it can very rarely be necessary to sever its sternal origin. When this has been done, much caution in the use of the knife is advisable. Many veins, much engorged if there be dyspnœa (sometimes the anterior jugular lies here), meander in this space; they and the loose fascia can generally be pushed away with the finger until the omo-hyoid is seen. Along the inner border of this muscle, as it lies on the sterno-hyoid, a few touches of the knife are required in order to allow of its being drawn upward and outward; the finger and a blunt hook will now turn and hold the outer edge of the sterno-hyoid inwards. The sheath, avoiding the descendens noni, is to be opened and the ligature passed as in the higher operation.[4] The unaccustomed operator should be prepared for having to go very deep, especially on the left side, where the vessel seems almost to lie in a pit.

After deligation of the vessel, the size of the aneurism may not much decrease, and pulsation, although arrested, may return after a very short time. This results chiefly from the very free communication of the vessels of the two sides at the base of the brain. Blood finds its way through the circle of Willis into the internal carotid of the affected side, and to that part of the common trunk which lies above the ligature, thence into the external carotid,

[1] I have generally seen here a very full, turgid vein, the superior thyroid, coming obliquely from the larynx to the internal jugular; it sometimes runs before, more often behind, the carotid. I suppose it is the effect of the anæsthetic, which causes this to swell to the size of a cedar pencil

[2] Pilz (Zur Ligatur der Art. carot. comm., Langenbeck's Archiv, Bd. ix. S. 399) says that the vagus has probably never been included in the ligature, but that a piece has been cut out of it; but that, on the other hand, the sympathetic nerve has been tied with the vessel. Neither of the cases to which he refers, was one of simple deligation—the former extirpation of a tumor, the latter a complicated deligation of several arteries for secondary hemorrhage.

[3] The length of the patient's neck and the position of the aneurism cause some slight variation in placing the incision.

[4] It is well to say that, in operating on the right side, more especially if a ligature which divides the inner vascular coats be used, the artery should not be attacked too low. The only case of fatal secondary hemorrhage which I have ever had in this operation, followed the ligation of a carotid with catgut close above the sterno-clavicular joint.

and so to the face and parts outside the skull. The operation, however, having relieved the blood-pressure, and the current being very indirect, coagulation, though slower than in arteries whose branches anastomose by less patent communication, nevertheless takes place. The nearer to the bifurcation is the opening between sac and artery, the slower *cæteris paribus* is solidification. I use the words " other things equal," because a large aneurism with a small mouth consolidates more quickly than a small one with a large orifice.

Before going on to study the mortality of tying the common carotid artery, it is necessary to consider its effects upon the brain. On this subject we have a variety of tables, which vary considerably; I will place their results in their chronological order:—

| | Whole number of cases. | Cases attended with cerebral complications. | Per cent. |
|---|---|---|---|
| Norris[1] | 138 | 30 | 21. |
| Ehrmann[2] | 213 | 47 | 22. |
| Pilz[3] | 482 | 154 | 32. |
| Lefort[4] | 241 | 73 | 30. |
| Wyeth[5] | 789 | 53 | 6.7 |

The death-rate of those affected with such symptoms varies, in these several authorities, from 56 to 73 per cent.

When we consider the marvellous freedom of circulation in the brain, and remember that its tissue must be saturated with nutritious fluid always migrating from the vessels, quite sufficient to last until the momentary local anæmia has passed away; and when we reflect that in consequence of hemorrhage at distant parts, or from other cause, complete syncope and coma often must render the brain all but bloodless for lengthened periods without permanent ill results, it is, I submit, impossible to attribute these alleged cerebral effects to the obstruction of one only out of four large streams that supply the organ. This view is greatly corroborated by certain cases in which, one carotid being already plugged, the other has been tied; and still more by 29 cases recorded by Pilz, in which one carotid was tied a certain time after that on the other side had been ligatured. Of these patients 8 died, 21 recovered. Among the fatal cases is one (Longmore) of gunshot injury, which appears to have been, rather than the operation, the immediate cause of death. Cerebral disturbance occurred in but five of these cases. Wyeth records 33 cases in which both carotids were tied at intervals varying from three days to six years (in one case of gunshot injury both vessels were tied simultaneously). Of these cases 9 only died, five of the deaths occurring in cases of gunshot wound and hemorrhage, and the fatal result being due to the injury rather than to the operation. So low a death-rate shows that cerebral anæmia can hardly be produced by tying a single carotid. The same thing is shown by the case of Dr. Smyth, who, 54 days after tying the right carotid, ligatured the vertebral on the same side; yet no brain symptoms were observed. Rossi, too, tied the right carotid of a patient who after death was found to have the left carotid and right vertebral obliterated; during the six days of his survival, the brain was nourished through the left vertebral alone. In no instance of tying the innominate, which operation cuts off all the right blood-supply of the brain, have cerebral symptoms been observed. We must, therefore, seek some other cause for the large percentage of brain complications ascribed by some authors to carotid deligation. I believe it may be

[1] I exclude the distal method and deligations undertaken for the cure of cerebral affections.

[2] Des effets produits sur l'encéphale par l'oblitération des vaisseaux qui s'y distribuent. Paris, 1860.

[3] Archiv für klinische Chirurgie, Bd. ix. S. 257.

[4] Gazette Hebdomadaire, 1864 and 1868.

[5] Essays in Surgical Anatomy and Surgery, p. 120. This author speaks of delirium, convulsions, and other slight cerebral symptoms as occurring in 18 other cases.

accepted that a very large majority of the cases in which so-called cerebral symptoms have supervened from the seventh to the tenth day, or later, were cases of pyæmia—a malady which twenty-five or thirty years ago was but little understood. Some of the deaths may have been due to detachment of minute portions of clot. Pilz infers from the small number of deaths when both carotids have been tied, that the brain trouble, when one only is ligatured, may be due to a want of balance in the circulation. However this may be, it cannot be denied that deligation of one carotid is sometimes followed by cerebral disturbance, a fact whereon Le Fort founded his recommendation to tie, whenever possible, the external rather than the common carotid. No doubt this advice is in accordance with those sound surgical principles which would forbid a large operation when a smaller one would suffice, and a possible complication, however remote, might be avoided. Dr. Wyeth[1] has, of late, even more strongly emphasized this view, and has supported it by numbers, finding that the death-rate of tying the external carotid is only four and a half per cent. It must, however, be pointed out that cases of aneurism suitable for this deligation must be very rare: in 91 cases of this procedure, aneurism (described as being in the parotid) is given but once as the cause of operation.

The statistics of carotid deligation for aneurism, have been collated by Norris (38 cases), Pilz (86 cases), and Wyeth (106 cases); but, for the purpose in hand, none of these collections can be accepted without some examination and sifting of the materials, since many of the cases belong to a category already studied as orbital aneurism, or to that of cirsoid aneurism; and since some of them are examples of mistaken diagnosis. We will take carotid aneurism, properly recognized, excluding all other cases; nor will it be necessary to refer more particularly here[2] to the work of older compilers, since their tables are included in the more modern record of Dr. Wyeth.[3] I have separated examples of aneurism from the rest, and have added one or two other cases. Thus are collated of deligations of the common carotid artery for aneurism of that vessel, or of a branch (exclusive of orbital or intra-cranial disease), cases, 107; recoveries, 77, or 71.96 per cent.; deaths, 27, or 25.23 per cent.; deaths from independent causes, 3, or 2.8 per cent.[4]

The causes of death may be stated thus:—

| | | |
|---|---|---|
| Hemorrhage | place not mentioned | 6 |
| | from sac | 2 |
| | from site of ligature | 1 |
| Inflammation, suppuration, or rupture of sac | | 4 |
| Exhaustion | | 1 |
| Pyæmia | | 2 |
| Inflammation of lung | | 1 |
| Cerebral complications | | 8 |
| Not stated[5] | | 4 |

[1] Op. cit., p. 132.

[2] Subtracting 8 of the cases given by Pilz, we have 78, of which 55 ended in cure and 23 in death; of these deaths, 2 are unrelated to either the aneurism or the operation (causes, cancer of rectum, and general atheroma). Thus the true life-rate and death-rate in the 78 cases are as follows: Recovered, 55, or 70.5 per cent.; died, 21, or 27 per cent.; died from independent causes, 2, or 2.5 per cent.

[3] Dr. Wyeth's collection of operations amounts to the astonishing number of 789. It is, I think, to be regretted that his table is arranged only according to the alphabetical sequence of the operator's names. Form of disease or injury, mistaken diagnosis, and chronology, are thus neglected, and the cases, being lumped together, require much sifting and examination previous to being used. Of his 789 cases, 328, or 41 per cent., proved fatal, a ratio much too high for aneurisms, and much too low for gunshot or other severe injuries.

[4] These numbers include eight distal deligations for carotid aneurism, but none for innominate or aortic aneurism.

[5] The number of deaths appears greater than that given above, because two cases appear under headings of both hemorrhage from sac and rupture of sac. Pilz records 12 deaths from hemorrhage, viz., 9 from the sac, 1 from point of ligature, 2 site not stated.

In considering the deaths from hemorrhage, we must distinguish clearly between those bleedings which spring from the site of deligation and those which arise from the sac. It is a pity that this distinction is not made in Wyeth's table. But I have been able to procure fuller information in many cases. Thus, in all the 107 deligations for carotid aneurism, bleeding occurred but twice from the site of ligature alone, and once from that place and from the sac simultaneously. This distinction is important, because, in a certain proportion of cases which must stand on the fatal side of the list, the operation affected the result neither one way nor the other: the sac continued to grow, and ultimately burst, just as though no operation had been performed. It appears, then, that we may accept a little over 25 per cent. as having been the mortality of this operation up to the present time, but it is probable that the immediate future will diminish this proportion very considerably.

The *old operation* for carotid aneurism was advocated by Mr. Syme as even the best primary procedure; but the vessel is badly placed anatomically, since it is difficult or impossible to command the circulation; and any surgeon who reads the account which Mr. Syme gives of his operation (a traumatic case), will hardly be induced to follow that eminent surgeon's example. If, however, the Hunterian operation have failed, and the aneurism continue to increase, the old method may be practised with comparative facility, since the ligature obstructs the artery sufficiently to make it safe. This has been done twice in America, and quite lately in London, by Mr. Morris.[1] No difficulty was experienced in the operation.

Aneurism of the Vertebral Artery.—This is always traumatic, following punctured wounds (stabs) at the side or back of the neck, or more rarely bullet-wounds. No instance of spontaneous aneurism has been, as far as I know, recorded. Although rare, 22 wounds and aneurisms of the vertebral artery have been collected.[2] The usual place of injury is between the first and second vertebræ, where the vessel makes its turn to pass outwards to the foramen in the wider transverse processes of the former bone; but in two cases it was between the second and third vertebræ; in one between the fourth and fifth; and in one (Kocher's) between the fifth and sixth.

Of great surgical interest is the diagnosis of these cases, the difficulties of which will be at once apparent when it is stated that, in more than half of the recorded cases, viz., in 12, the disease was mistaken for aneurism of some branch of the carotid; and that in 11 cases that vessel was tied, while in one the inferior thyroid was supposed to be the wounded vessel (Maisonneuve), and tied first; but afterwards, since bleeding did not cease, the vertebral also was ligatured.

The *situation* of the wound helps but little in the diagnosis; in most cases this has been near the skull, and about an inch behind the mastoid process; hence the surgeon is very likely to attribute the bleeding or the aneurism to the occipital artery, or, if the injury be lower, to the ascending cervical. In certain other cases, the penetrating wound has passed through quite different parts, namely, "mouth" (twice), "cheek," at "the angle of the jaw," "under the ear," etc., where certainly a branch of the carotid would appear to be more exposed to injury than the vertebral. Since, then, situation of the wound gives no certain indication, the only method is to observe whether

[1] Medico-Chirurgical Transactions, vol. lxiv. p. 1.

[2] Sixteen have been gathered by Barbieri, of Milan; four are mentioned by Pilz; and the other two are the cases of Lücke (Langenbeck's Archiv, Bd. viii. S. 78) and of Kocher (Ibid., Bd. xii. S. 867).

pulsation ceases—or, in cases of wound, whether hemorrhage is arrested—by pressing on the carotid; but it is just this pressure, exercised in the usual way, but with insufficient consideration of its effect, that has so completely misled diagnosis in the large number of cases above referred to.

The place usually chosen for compression of the carotid artery is the transverse process of the sixth cervical vertebra, or perhaps, since the skin and fascia tend to bear the finger upward, a little below this point. Now this pressure, properly carried out, will certainly check all pulsation in the carotid and its branches, or in their aneurisms; but surgeons, founding upon this fact a diagnosis of carotid aneurism, have been led into grievous error, because they have not remembered that such compression must infallibly affect the vertebral also. Even if the carotid be compressed against a transverse process higher up, there yet will remain a source of error in the irregularity of the vertebral, which occasionally does not pass into the chain of foramina until it reaches the axis. Hence the only means of secure diagnosis is by pinching the vessel, after Rouge's method (p. 497), with the finger and thumb behind the relaxed sterno-mastoid, while the soft parts are drawn a little forward—away, therefore, from the spine, and not pressed against it. By this means, doubtless, an accurate diagnosis may be arrived at.

*Treatment of Vertebral Aneurism.*—The treatment of these cases has not been fortunate; indeed, only two—those of Möbus[1] and Kocher—have ended favorably. This infelicitous result is doubtless in part owing to mistakes of diagnosis, but also to inherent difficulties in the anatomical arrangement of the parts, which is such as to preclude the use of many of the means usually at our command. *Pressure* on the lower end of the vertebral could certainly not be borne without an anæsthetic long enough to have any effect on a traumatic aneurism; nor do I think, seeing how free is the intercommunication of vessels at the base of the brain, that the prospects of a good result would be sufficient to warrant an attempt to cure by proximal pressure after the rapid method. The *injection* into the sac of perchloride of iron could not be effected under the principles necessary for success, namely, occlusion of the vessel, at least on one side of the aneurismal sac; while the danger of the clots and the solution being carried into the brain, is very evident.[2] The same may be said of *galvano-puncture*, though that might be more safely used, since the clots formed by the current are less persistent. The *parenchymatous injection of ergotin*, unless the rapidly growing sac demanded the immediate use of more potent measures, might certainly be tried. Probably, however, in most cases, carefully applied direct pressure and the application of cold will be found the most efficacious of all the non-operative measures.

As already said, only two cases have ended well, the first being that of Möbus—a traumatic aneurism which was judged to be formed on a branch of the carotid; the vessel was exposed, and the aneurism needle passed round it, when pressure on the curve of the instrument being found not to restrain pulsation, the wound was closed. The patient refused to submit to further operation, and under the application of cold the aneurism consolidated.

The successful case of Kocher was one of stab on a level with the interval between the fifth and sixth cervical vertebræ. The wound had been received three weeks previously, giving rise almost daily to hemorrhages, which had been treated with pressure and the application of pads steeped in the liquor ferri perchloridi. Kocher introduced his finger, enlarging the wound pretty freely, and removing laminated, discolored, and loose, dark clots. He then

[1] Gräfe and Walther's Journal, Bd. xiv.

[2] The only case thus treated (Lücke) died with brain troubles, repeated injections having probably much to do with the result.

found that by pressing from above on the sixth, or from below on the fifth, transverse process, hemorrhage was arrested. He could even seize the bleeding point with long forceps, but it was impossible to tie any vessel, "as the ligature had nothing to grip." He therefore introduced a pad, the size of a pea, steeped in perchloride of iron, upon the bleeding spot and well between the transverse processes. Most fortunately this device succeeded, and the patient recovered without further trouble.

The case is thus shortly related to show what difficulties the surgeon who should attack such a case by the old (Antyllian) operation might have to encounter, for the aneurism is partly situate between the bones, and nothing would be found that could be tied.[1] A firm plug of lint, as in the above case, might prove successful, but the inference to be drawn is rather to avoid operation, unless it be actually forced upon the surgeon.

The device proposed by Gherini to lay bare the transverse processes above and below, sufficiently to permit the passage of an armed needle inside the course of the vessel, over and below its wound, is fraught with difficulty and some uncertainty, but in case the plug did not fulfil its object, the method might be tried in spite of the danger of wounding a nerve trunk as it passed from the spine. Were all these methods to prove ineffectual, a last resource, one almost of despair, would be to tie the vertebral both below the sixth and below the first vertebra.[2]

## Aneurisms at the Root of the Neck.

In tracing the carotid vessel lower down, we come to the *root of the neck*, a region in which several forms of aneurismal tumor may show themselves. It appears to me, therefore, advisable to class all these aneurisms together under one general title, as thereby we shall avoid unnecessary repetition or wearisome reference. Under this head are included *low carotid*, *subclavian*, and *innominate* aneurisms, as also those *aortic* aneurisms which, springing from the first or second part of the arch, make their appearance above the sternum or clavicles, and always affect the upper two or three intercostal spaces of the chest. By this arrangement it is not intended to lump or confuse together these different forms of disease, but rather by comparing them to draw distinctions, more closely contrasted. We have, then, many forms of the disease to study here: two involving the subclavian (1st and 3d parts); one, the lower part of the carotid; two, the innominate (high and low); and several forms of aortic aneurism,[3] all liable to make their appearance within a very limited space.

Aneurism of the Third Part of the Subclavian Artery.—This frequently manifests itself by very severe, neuralgia-like pains, running from above the collar bone down the arm, and to the back of the shoulder, before any distinct swelling is noticed; indeed, I have seen two cases in which such distressing pains, lasting for two months, had almost worn out the patient before aneurism was detected.[4] When enlargement becomes perceptible, it

[1] An authority on aneurism, writing in the Lancet, proposes this operation in vertebral aneurism; but as is seen from the result of treatment when the disease is about the tarsus (p.453), the method is hardly applicable when the sac and its vessel are inclosed in bones.

[2] In the dead subject it is quite possible to tie the vessel as it makes its turn between the axis and the atlas.

[3] I shall presently have occasion to point out the essential differences between aneurism of the ascending aorta and of the proximal and distal portions of the transverse aorta.

[4] Nevertheless, this symptom is by no means conclusive. In 1878, a gentleman avoided a fall at a fence by hanging forcibly to a hurdle stake; pains, such as described in the text, super-

first shows itself above the middle, or rather a little outside the middle, of the clavicle; frequently that bone is very early in the case pushed forward, and soon beats with a communicated pulsation; especially is this the case in feeble persons and in women. When the shoulder begins to rise, one may see the throb in the little triangle bounded above by the clavicle, at the sides by the deltoid and greater pectoral. In all cases, the pulsation is strong, while the radial pulse on the diseased side is weakened. The aneurism, unless it encroaches on the proximal part of the vessel, never pulsates in the episternal notch; venous congestion of the arm only comes on when the tumor is large; congestion of the face and neck is absent.

The disease is peculiarly liable to begin about the lower margin of the first rib, and to spread thence either downward, when it becomes high axillary aneurism, or upward, when it comes under the category of pure subclavian aneurism; not infrequently it spreads in both directions; it is then subclavio-axillary. The extension upwards is, as a rule, checked by the scaleni, which, supporting the vessel on all sides, prevent dilatation; but in some cases, those, namely, in which atheroma extensively affects the whole arterial system, the second part may be involved with the first, or with the third; or, indeed, the whole vessel, from beginning to end, may be affected generally by dilatation (fusiform aneurism). In such cases, the tumor is very generally constricted where it passes between the scaleni, so as to assume an hour-glass form. Aneurism never, I believe, begins in the second part of the vessel.

The pressure symptoms vary somewhat according to the size of the tumor, its exact place on the vessel, and the direction of its growth; thus, while pressure merely implicates the nerves of the arm and shoulder, with slight enlargement of veins—chiefly those about the acromion and the external jugular—we have to do with an aneurism of only the third part, or encroaching but slightly on the second; but more marked venous congestion, especially if it implicate only the arm and hand, points to extension of disease towards the axilla. If, on the contrary, the face and neck—the whole jugular venous system—becomes engorged, the disease is intruding inwards towards the first part of the artery; and this diagnosis is greatly strengthened if some loss or diminished resonance of voice, and a certain teasing, irregular, laryngeal cough, be observed.

The third part of the subclavian artery is aneurismal about six times as often as the first part,[1] and is three and a half times more common on the right side than on the left, and about ten times more frequent among men than among women. In about one-eleventh of all the cases of subclavian aneurism, the first part alone of the vessel (on the right side) is involved, and even of this proportion the immunity of the rest of the artery is in a certain fraction doubtful. The first part of the left subclavian artery develops aneurism (unless merely as forming part of aortic disease) very exceptionally.

Aneurism of First Part of Subclavian Artery.—An aneurism of the first part of the right subclavian shows itself by a tumor, which generally appears under the clavicular part of the sterno-mastoid muscle; it lies, therefore, a little outside the place where carotid aneurism first appears. The shape

vened, and gradually increased, for four months; after that time he came to me, and, on examination, I found the subclavian artery, which lay high, beating violently. The space, however, was puffy, and swollen beyond the limit of pulsation; the artery appeared to me flattened rather than dilated; but in a case of such difficulty and importance I conceived it my duty to ask for a consultation. Sir J. Paget, examining the case with me, confirmed my view of its non-aneurismal nature, and expressed the opinion that neuritis of the brachial plexus produced the pains and pressed the artery forward. Under treatment founded on this diagnosis, and on the gouty habit of the patient, he slowly recovered.

[1] I include subclavio-axillary aneurism in this computation.

of the swelling is a rather elongated oval, the long axis oblique, the lower part of the tumor being covered by the clavicle; it may, indeed, protrude and pulsate also just below that bone. If the shoulder be raised, this bone glides over the tumor until the whole of a moderately small, or only part of a larger aneurism, is thereby concealed. If large, an aneurism in this situation may press the clavicle forward until subluxated.

Certain pressure-symptoms are well marked. The first is usually a teasing cough, with altered voice, from slight stretching of the recurrent laryngeal nerve; then the internal jugular vein becomes distended, and may be seen engorged at the lower part of the neck. The tributary veins are also full; this is especially the case with the external jugular, which, assuming part of the deeper vessel's office, becomes often exceedingly large. At a somewhat later period the veins of the hand and arm swell, and then those of the front wall of the axilla.

As the tumor increases in size, so are these symptoms aggravated. Irritation of the larynx yields to paralysis of the vocal cords; the veins of the neck, arm, and side become fuller, and these parts may even become varicose; the radial pulse is weaker than on the other side, and, indeed, is sometimes barely or even not at all perceptible.

There is frequently some difficulty in distinguishing low-carotid, subclavian (of first part), innominate, and even, strange as it may seem, certain aortic aneurisms, from each other. Diagnostic signs are chiefly derivable from comparison of the radial and carotid pulses on the same side. If the innominate be unaffected, the beat of the carotid is not altered; hence a pulsating tumor above the clavicle which greatly affects the radial, but not at all the carotid pulse, is purely subclavian; the innominate is involved if the impulse of both vessels be modified. Moreover, a purely subclavian aneurism is hardly ever to be felt in the episternal notch; while innominate and proximal aneurisms of the aortic arch can very nearly always be detected in that situation.

Carotid and subclavian (first part) aneurisms of the left side are more easily differentiated, the absence of an innominate rendering them independent of each other. The first part of the carotid—namely, that between its origin and the sterno-clavicular joint—is only the subject of aneurism as forming part of aortic disease. The same may be said of the intra-thoracic portion of the subclavian. It need hardly be said that in subclavian aneurism of the left side, laryngeal symptoms are absent.

Low Carotid Aneurism.—The tumor, while yet small, is felt to beat in the angle between the sternal and clavicular portions of the sterno-mastoid muscle; and when that muscle is relaxed, so that the finger can be passed behind its inner portion, the rounded margin of the pulsating swelling can there be distinctly made out. As the size of the aneurism increases, its inner edge comes to lie inside this muscle, and may be felt in the right[1] portion of the episternal notch. The tumor, if ovoid in shape, has its long axis directed upward and downward. The impulse is upward. I do not, of course, mean that the blood-stream can actually be felt, but that the expansile wave is in that direction. The pulse of the carotid above the aneurism, about on a level with the thyroid cartilage (where it is most easily felt), is decidedly weaker than on the left side, as is also the beat of the arterial branches—the facial on the lower jaw, and the temporal; I rely rather upon the extremely facile compressibility of the arteries than on their mere weak beat. This peculiarity is carried even into very small branches, for if the patient's ears be nipped simultaneously and with equal pressure for a few seconds, between the finger

[1] The aneurism is supposed to be of the right carotid.

and thumb of each hand, and then suddenly released, the white mark thus produced will regain its color more slowly on the diseased than on the normal side. These signs show that the carotid artery is aneurismal.[1] We now must discover if it alone be involved. The "exclusion signs," as they may be called, are these:—

There is no sign of pressure on any vein, nor, unless the tumor be very large, on any nerve; larynx, trachea, and œsophagus are all unaffected. Until the sac is large enough to press on those tubes, the radial pulses are alike and unaltered; percussion-sounds of the parts below the sterno-clavicular joint are normal; unless of course the lung happen to be diseased, there is no dulness over the first rib and intercostal space.

It is assumed in the above paragraphs that the aneurismal nature of the tumor has been distinctly verified; nevertheless, I would point out that it is well to give the patient a little water, and while he is swallowing to watch the behavior of the tumor—if it rise with the trachea or remain stationary. It is well to point out that the lower, like the upper, part of the common carotid, is in women occasionally the subject of a peculiar condition, which although anatomically abnormal, is yet not the result of disease. I have never had the opportunity of investigating this peculiarity after death, but, from study during life, the condition appears to be the result of the mode in which the innominate divides, incorrectly represented in anatomical works. The received idea of this bifurcation is, that the two vessels arise side by side from the end of the parent stem—in reality they spring one posterior to the other, the subclavian behind. Now, in most persons, the carotid runs straight from this point to its bifurcation, leaving a little space, the thickness of the clavicle, between itself and the sterno-mastoid, just above that bone; but in other persons the vessel bends forward over the upper border of the clavicle, touches—even flattens itself a little—against the fascia between the two parts of the muscle, and then swerves back again. The most prominent part of this curve pulsates visibly, sometimes strongly. The sense of touch will, however, distinguish this beat of a perhaps slightly dilated artery, from that of aneurism.

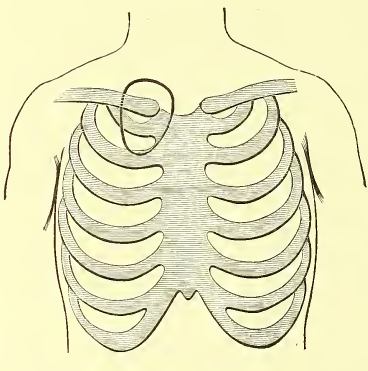
Innominate Aneurism, pure and simple, is not a common disease, the trunk being so short that either one or both of its branches, or its root on the aorta, are involved, either at first or soon after the commencement of the disease. Indeed, clinical experience convinces me that many cases of innominate aneurism begin at one or other end of the vessel. Thus, as with carotid aneurism, we encounter a high and a low form of the disease, the symptoms of which are different. Nay, more, the high form, which term indicates participation, perhaps commencement, of the disease in one or other derivative, exhibits different symptoms, according as it begins on the carotid or on the subclavian aspect of the vessel. These differences chiefly regard the results of pressure. Some ambiguity may, however, be produced by a form of aneurism, purely aortic, which, springing from the front of the arch, near the root of the brachio-cephalic trunk, expands in front and in the direction of the latter vessel, occupying anatomically very much the same place as the disease under consideration.

The tumor of an innominate aneurism generally occupies the episternal notch, but chiefly on the right side, and, even though it may not rise high, takes up the whole breadth of this space. On gently pressing the finger backward and downward, the rounded margin of the sac can be felt. After

[1] It is true that some other forms of aneurism may compress the lower end of the carotid, and obscure the symptoms; these forms are detected by the signs now to be specified.

a little time, the sternal end of the clavicle protrudes abnormally and partakes in the pulsation (communicated), while the sternal and afterwards the clavicular portion of the sterno-mastoid is also pushed forward. Not unfrequently the first costal cartilage, outside where it joins the sternum, is also abnormally prominent, and throbs with the beat of the tumor. These parts are dull on percussion; there is a peculiarity in the dulness of aneurism, which should be observed, namely, that in the centre it is complete, but at the circumference, on each side, incomplete or relative, gradually, as we go outwards, merging into the clear percussion note. Downward, the want of resonance usually mingles with the normal, aortic, and further downward and to the left, with the cardiac dulness. But occasionally, especially if some dyspnœa exist, a significant, resonant space lies over the sternum, between the second costal cartilages, dividing the cardiac from the tumor dulness. Its appreciation depends on the mode of percussion; gentle taps elicit hyper-resonance; heavier blows the deeper dulness. This condition is produced by an emphysematous lung-margin, overlying the commencement of the aorta. The pulsation is most marked where dulness is most complete, but extends even into the limits of relative dulness. Occasionally, a pretty evident throb may be felt beyond the dull region. The area of pulsation, until the tumor is large, may be taken as in the annexed diagram. The stethoscope detects over all this space the heart-sounds, with exaggerated distinctness; but they are altered in a way that has been insufficiently, if at all, pointed out, viz., while both are heard as plainly as, perhaps even more plainly than, over the cardiac space itself, it is the second sound which is more especially exaggerated, and this is often louder than the first; the thinner the wall of the aneurism, and the freer from any lining of blood-clot, the more predominant is this second heart-sound. The pulses of the right radial, and of the carotid and its branches, are altered, weak, and compressible.

Fig. 543.



Area of pulsation in early innominate aneurism.

These signs are such as we meet with in the form of disease which affects the upper part of the trunk, and either commences in or tends to carotid complication. But cases occur in which the tumor lies more outward in the episternal notch, and in which it may be felt along a certain distance of the clavicle, the symptoms being those of innominate and subclavian aneurism combined.

The pressure symptoms of innominate aneurism are very variable: sometimes slight, sometimes remarkably severe. If the *high form of the disease* be on the inner aspect of the artery, there is at first a constant, teasing cough; this afterwards gives place, as the tumor grows, to dyspnœa, with paroxysms of coughing and breathlessness that seem about to prove fatal, until relieved by discharge of mucus or muco-pus. No venous pressure is demonstrable until the disease has attained considerable dimensions. When the tumor lies

outside the episternal notch, there is at first an abnormal voice, tending to break into falsetto, afterwards want of tone, and then aphonia, with a tendency to "swallow the wrong way;" and about this time congestion of the left arm and of the left side of the head and neck. There is no dyspnœa until the tumor has become large.

The *low form of innominate aneurism*, as it is usually combined with aortic disease, must be considered with that subject hereafter; but it will be well to point out here some remarkable peculiarities in the pressure symptoms. There are respiratory complications—paroxysmal metallic cough without aphonia, and marked dyspnœa. But the point to be especially remarked is this: the pulsation, dulness, abnormally loud heart-sound, etc., are on and to the *right* of the middle line; the venous congestions are on the *left* side of the body, nor does the right participate till late in the disease. The very free communication between the cephalic vessels renders this less evident in the head; but the veins of the forearm and upper arm look in such cases almost varicose, and a meshwork of blue vessels overlying the left pectoral region is especially striking. A peculiar, soft tumor, sometimes described as spongy, but giving a sense of being made of worms, smaller than those felt in varicocele, forms over the left clavicle—a very characteristic symptom. When the right side is also involved, the aneurism will have become large; the amount of dyspnœa and of exclusion of air from the lungs must decide whether this participation results from pulmonary congestion, or from pressure on the descending cava or right innominate vein.

*Treatment of Aneurisms at the Root of the Neck.*—Before going on to study the surgical treatment of innominate aneurism, which I shall take up with that of the aortic arch, it will be well first to consider the measures available for the other forms just described, assuming that no one would proceed to operative measures until rest, diet, one or other form of pressure, and perhaps some other of the methods already mentioned, had been fairly tried, and had failed to produce any lasting benefit. The word "lasting" is used here because there are few cases, subject to rigid rest and unirritating diet, which fail to exhibit signs that simulate improvement. The heart and the vessels being in repose, it is only natural that the aneurism should pulsate with less force; and, unless its coats be very thin, that it should, by the mere elastic contraction of its walls on a less potent blood-stream, diminish in size. No doubt, in a certain number of cases, this immediate result is followed by material improvement, or even by cure. Other patients, having simply reached that point, progress no further. Week by week, or oftener, a full examination shows the disease in the same state; at last the exigencies of life require resumption of occupation;[1] when movement and employment immediately bring back the old rate of growth. Another and the larger series of patients experience some immediate benefit from the rest and restrictions, for the first few days; after which, and even while treatment is going on, the disease resumes its rapid progress. Under either of the two latter conditions, surgical measures should be resorted to.

*Rest and Diet.*—I find, of aneurisms of the subclavian, 31 treated by rest and regulation of diet, and 13 subjected to the stricter regimen and the venesections of Valsalva. Of those in the former category,[2] 4 were cured, but 2 of them so rapidly, or rather suddenly, that the event was evidently due to some

[1] These are the cases which, in Hospital Reports, are noted as "relieved."

[2] Poland gives 22 cases; the additional 9 are from my own sources, chiefly from Hospital Reports. There is no doubt that many more have occurred in different parts of the world; but a case of aneurism treated by means so little noticeable, increasing and killing the patient, would hardly find its way into print.

fortuitous impaction of clot. Cure can only be ascribed to the influence of treatment in the 2 cases which recovered slowly, that is, by gradual consolidation.

Of 13 patients subjected to Valsalva's method, 7 are reported as cured, or in process of cure; but on examination this number shrinks considerably: 2 cases (Guérin) are very likely one and the same; 2 are doubtful as to the nature of the tumor; 1 patient was not cured, passing from observation almost immediately after treatment had been begun, and with little benefit; in 1 spontaneous cure fortuitously began with or before the treatment; 1 got well during acute enteritis; 1 recovered under the influence of a poisonous dose of aconite (Pancoast).[1]

*Compression.—Proximal compression* was rendered facile in a case under the care of Mr. Poland, by an arterial abnormity combined probably with the development of a cervical rib. The aneurism was cured. Another successful case recorded by Dutoit, is referred to in the sequel.

Of the results of *direct compression*, it is hardly possible to acquire any accurate numerical knowledge; probably nearly every quickly increasing aneurism has, at some part of its course, been restrained, or attempted to be restrained, by some bandage or pad; and a few of these cases have got well, as in Yeatman's case, without any clear sequence between treatment and cure;[2] or an accidental detachment of clot, as in Corner's case, has occurred under a protecting leather cap;[3] or an accident rupturing the aneurism has caused, by the blood-pressure, obliteration of the artery and afterwards suppuration;[4] or, as in another case[5] recorded by the same surgeon, the ten days' very moderate pressure may have set up the first increment towards gradual consolidation; or the cure may have been fortuitous and spontaneous. Indeed, the only clear case of cure by direct pressure is that of Mr. Holmes.[6] The tumor was the size of a chestnut, and lay on the third part of the vessel; the index finger was gangrenous. The arm was enveloped in cotton-wool, and an India-rubber ball was bandaged upon the swelling with gradually increasing pressure, for about six weeks, and after five days' intermission was again employed for ten days; after this, an instrument was adapted. Gradual consolidation took place; and the man was seen a year afterwards with barely a trace of the disease—a most gratifying result, which should encourage a trial of this method, but a result which we cannot expect frequently to follow, unless, as in this instance must have been the case, there exist a great tendency to spontaneous cure.[7]

*Manipulation* is a mode of treatment suggested by events which occur spontaneously with such frequency that we should not exclude it from our resources, especially in dealing with a disease which offers to the surgeon so few points of vantage. It should be very cautiously resorted to in subclavian aneurism; the danger of embolism in the brain, through the vertebrals, and on the right side through the carotid also, must be duly weighed.

[1] In my table I have marked one of the Guérin cases as doubtful, put two others in the same category, and relegated the one not cured to its proper place, as also those influenced by poison and disease; this leaves one case as cured by Valsalva's method.

[2] Med. and Phys. Journ., vol. xxxiii.

[3] Medico-Chirurgical Transactions, vol. lii. p. 303. Mr. Corner entitles his case one of Right Subclavian Aneurism cured by Direct Compression; and Mr. Poland has accepted this nomenclature. The first treatment, rest, diet, and ice, resulted in "no benefit;" then "a leather cap was moulded to the swelling and fixed on by straps." The patient resumed his occupation, and there is no note of improvement. A year afterwards "he felt himself suddenly bad, experiencing sickness and vertigo, so that he was obliged to hold on to something to prevent his falling; and on feeling the swelling afterwards no pulsation was found in it." No clearer evidence of accidental clot-impaction is possible.

[4] Warren, Surgical Observations, p. 425.

[5] Ibid., p. 427.

[6] Lancet, Feb. 12, 1876.

[7] A case by Dutoit, in which pressure aided other means, will be mentioned immediately.

I find this mode of treatment noted five times in the Hospital Reports of the last ten years, and each time as unsuccessful; while of the five cases quoted by Poland, in only one was it of avail.[1]

*Parenchymatous injections of ergotin* appeared to be of decided benefit in the case of Dutoit, the cure being confirmed by distal pressure.[2] The case, as I read it, was one of fusiform dilatation of the left subclavian, just before it passes between the scaleni. Dutoit used large doses, beginning with half a grain, and rapidly increasing to three grains. After the fourth injection, the tumor began to diminish, while the surrounding tissues became exceedingly hard. After about three weeks, distal digital pressure became possible, and was used during six days—in all twenty-one hours. The aneurism became solid. But three more injections, and then an India-rubber pad and bandage, were employed. The treatment occupied five months. This case gives the most potent evidence on record that such injections may be valuable. In Langenbeck's case, that which laid the foundation of this treatment, the ultimate benefit was doubtful. I find no other instance of advantage derived from this plan; but it has very frequently been used without any good result.

*Injection into the sac of perchloride of iron* has not proved beneficial, and its dangers are very great, since it is impossible to obviate the flow of solid or semi-solid blood-clots along the vertebrals.

*Temporary ligature* and *acupressure* have proved even more surely productive of secondary hemorrhage than has permanent deligation. These plans were tried by Porter and Bickersteth, and will be referred to in the sequel.

*Amputation at the shoulder-joint* was suggested and practised by Mr. Spence,[3] and the method has since been adopted by Holden,[4] Heath (who, after amputating, also thrust needles into the sac),[5] H. Smith, Rose, and Bellamy.[6] Mr. Spence's patient seems never to have quite lost pulsation in the aneurism, though he survived four years. Rose also tied the carotid, and thus succeeded in curing his patient. In the other cases the procedure was unattended by any benefit.[7]

The results of these methods may thus be tabulated:—

| Treatment. | No. of cases. | Cure by treatment. | Coincident cure. | Death or no benefit. | Doubtful cases. |
|---|---|---|---|---|---|
| Rest and diet | 31 | 2 | 2 | 27 | |
| Valsalva's method | 13 | 1 | 2 | 7 | 3 |
| Proximal pressure[8] | 1 | 1 | | | |
| Direct pressure | ? | 1 | | | |
| Manipulation | 8 | 1 | .. | 6 | 1 |
| Coagulating injection | 2 | .. | .. | 2 | |
| Injection of ergot[8] | 6 | 1 | .. | 4 | 1 |
| Galvano-puncture | 3 | 1 | .. | 2 | |
| Temporary ligature | 2 | .. | .. | 2 | |
| Amputation at shoulder-joint | 7 | 2[9] | .. | 5 | |

[1] Fergusson's second case cannot be regarded as cured by the manipulation.

[2] Langenbeck's Archiv, Bd. xii. S. 1070.

[3] Spence, Med.-Chir. Trans. vol. lii. p. 306.

[4] St. Bartholomew's Hospital Reports, vol. xiii.

[5] Med.-Chir. Trans., vol. lxiii. p. 65.

[6] Unpublished. A case of ruptured artery after dislocation reduced by another surgeon. In the engorged condition the artery could not readily be found.

[7] In Morton's case (Pennsylvania Hospital Reports, 1868), amputation of the arm and subsequent removal of the caput humeri, were undertaken for secondary hemorrhage after deligation of the second part of the artery, rather than for subclavion aneurism; the man recovered.

[8] I have placed the case of Dutoit among the successes by injection of ergot, and also by proximal pressure; he insists upon this latter, but I do not understand how it was applied.

[9] One of these cases (Morton's), referred to a few lines ago, was hardly an amputation for aneurism. Spence's patient lived, but the aneurism was not cured.

*Ligature of the subclavian artery in its terminal division*, for aneurism of the same tract of the vessel, would, at once, strike the surgical pathologist as a very hopeless procedure, (see p. 490), and we find that in the five cases in which this has been attempted, death resulted in three,[1] a mortality of sixty per cent. But if the aneurism be subclavio-axillary, and do not reach as high as the border of the scaleni, a better prospect is afforded.[2] Thus, for such disease, the vessel has been tied over the first rib twenty-eight times, with sixteen recoveries and twelve deaths; hemorrhage was the fatal complication in five cases.

The small number of cases in which the second part of the subclavian artery has been tied for aneurism, is probably due to an exaggerated idea of the difficulties of the operation. I cannot but think that this deligation might, with advantage, be substituted for that of the third part in a large number of cases, since, as already pointed out, the vessel is less often diseased at the spot where it is supported by the muscles, than elsewhere, and usually only one branch is given off from that part. I can find only nine cases of this procedure, with but four recoveries and five deaths. In analyzing the causes of death we find that only one patient died of secondary hemorrhage (Liston), and one of cerebral complications, the cause being obscure; two cases of diffused traumatic aneurism[3] terminated fatally by pyæmia, and one patient died of drunkenness when nearly recovered (Gay). Thus four deaths out of the five may be considered as not intimately connected with the operation, and we may, therefore, regard them as almost fortuitous.

We have still to record seven cases in which the aneurismal sac so covered the artery that it could not be reached without exposing the patient to unjustifiable danger. Of these cases of commenced, but abandoned, operation, five ended in death; one was followed by cure (probably the result of manipulation); of one, the result is unknown.

*Deligation of the first part of the subclavian artery*, or of the termination of the innominate, is an operation which the surgeon would only undertake under very pressing circumstances; indeed, high authorities have pronounced it unjustifiable. But that judgment was given, and the experience whereon it was founded was acquired, before the modern improvements in the material of ligatures had been introduced. I should not, in a suitable case, decline to tie either of these vessels, although the statistics of the past (had we still to rely on silk or hemp), would, undoubtedly, deter me from any such undertaking.[4] These statistics are as follows: eleven patients have been subjected to this operation, of whom every one died—one from pericarditis, pleurisy, and pyæmia, and nine from hemorrhage, the cause of death in the eleventh (Arendt's) case being unknown. In a twelfth case (McGill's), in which the artery was compressed with torsion forceps, death resulted from a wound of the pleura. The bleeding in the nine cases referred to took place from the distal part of the vessel, that is to say, from beyond the ligature. Thus it appears that free collateral circulation keeps the part of the vessel on the further side of the heart open, so that when the artery is ulcerated through, blood passing along the branches, enters the trunk, and makes its exit from the peripheral end of the severed vessel. For this reason Liston and Cuvillier

[1] One of Mr. Poland's cases was in reality a deligation of the second part, and I find, since the date of his papers, another case similarly incorrectly classified.

[2] The difficulty of determining, before exposing the artery, the exact height at which such disease may stop, is undoubted; after laying the vessel bare, however, the surgeon has the choice of placing his ligature behind the scalenus.

[3] In reality a wound of the artery; it is the comparative absence of hemorrhage, that very fatal result of more central operations, on which I would especially rely as supporting the recommendation given in the text.

[4] The method of performance is given at p. 513.

tied also the carotid, while Parker ligatured both that vessel and the vertebral. The results, however, disappointed the expectations of the operators, and bleeding occurred in the same way. In nine cases, in which the first part of the subclavian only was tied, the operation was undertaken for the cure of subclavian aneurism, and in one case for that of axillary aneurism; these, with Arendt's and McGill's cases, and the three in which other vessels also were ligatured, make up the number to fifteen, of which all, save three, are known to have terminated fatally from hemorrhage. A sixteenth case (Hobart's) belongs to and will be found in another category (aortic aneurism), while three cases (tabulated by Wyeth), in two of which the vessel was secured for gunshot wound, and in the third for vascular tumor of the scalp, do not belong to our subject; all four patients died of hemorrhage.

An alternative lies between this operation and *deligation of the innominate*, but in this choice statistics guide us very little. There have been twenty-three examples of this procedure,[1] and death has resulted in twenty-two. In the one which survived, secondary hemorrhage occurred; Dr. Smyth, of New Orleans, had tied, at the same time, both the innominate and the carotid; fourteen days afterwards, hemorrhage occurred, and was repeated, but less copiously, at intervals. At last, fifty-four days after the first operation, the vertebral was tied; the patient after this did well, and survived ten years, ultimately dying, however, of hemorrhage from the sac.

When we consider the results of these forty-two cases of subclavian and innominate deligation, we are first struck by the frightful death-rate, and, going further, by the fact that the hemorrhage has invariably come from the distal part of the vessel. This is accounted for by the very free anastomoses in the neck, but principally by those of the vessels at the base of the brain. If the subclavian (first part) be alone tied, blood finds its way down the thyroid axis, but more especially, down the vertebral into the vessel beyond the ligature, while tying also the common carotid helps but little, since blood readily passes down that artery into its branches, and so to the subclavian, as well as by way of the vertebral artery. The same thing occurs as in the last case, if the innominate alone be ligatured. Thus a question naturally arises, namely, if a certain sort of ligature could be trusted to effectually prevent secondary bleeding (the vascular coats being undivided), would deligation of the vessel cure the aneurism, unless other arteries—carotid and vertebral—were also tied? This question can only be answered by experience, such as we have as yet had little or no opportunity of acquiring. It must be remembered that a certain current through the aneurismal sac is advantageous, but we do not as yet know whether the collateral flow would not, in a large proportion of cases, be so rapid as to prevent consolidation. The condition of the aneurism is described in a few only of the recorded cases; but in most of these the sac is said to have been contracted, much thickened, and filled with clot or with laminated fibrin.

*Deligation of the right subclavian artery in its first part.*—The operations of tying the first part of the right subclavian and the innominate are very similar. About six slightly different modes of making the first incisions have been practised. Two only need be mentioned, viz., the method by a single transverse or oblique incision, and that by two incisions meeting at an angle: this last is the one which I should recommend.

Begin about $2\frac{1}{2}$ inches above the sterno-clavicular joint, and over the round belly of the sterno-cleido-mastoid muscle. Make an incision ending on the clavicle a little outside the articulation; from this, carry outward another in-

[1] Including the case recently recorded by Thomson, of Dublin. See Appendix to this Article, p. 538.

cision over the bone to a little beyond the limit of the muscle; turn the triangular flap upward and outward, tying and cutting, if necessary, the external jugular vein; then the outer edge of the sterno-mastoid being found, a director may be passed behind it[1] as far as its sternal origin, and all the clavicular portion divided. This being pushed on one side, exposes the fascia over-lying the sterno-hyoid; the director, after a little opening in the aponeurosis has been made, can be insinuated behind that muscle, which also must be severed. It is well now to look and feel for the carotid artery before going on to divide the sterno-thyroid, whose outer edge covers that vessel, and never, as far as my experience of the dead subject goes, conceals the subclavian.[2] The finger of the operator, after division of the sterno-hyoid, readily detects the longitudinal course and pulsation of the carotid, and may with ease push the edge of the sterno-thyroid from off its sheath, inward, in which position the muscle should be held with a blunt hook. When thus the sheath of the vessel is brought into view, the operator should look for the large veins that always, but more especially if there have been dyspnœa, overlie it. Choosing a vacant spot, he merely nicks the loose structure in which they lie, and then pushes them up and down, tearing the cellular tissue a little, till the dense fibrous sheath is bared sufficiently—first, to have a small opening made in it, and then to be slit up. This should be done on the front, inner aspect. Now, at this part the vein diverges a little from the artery, so as to leave a triangular interval through which the vagus nerve runs. A blunt hook is placed over this, and it is to be drawn with the jugular vein gently outward. The next point is to find the subclavian. To do this the operator must remember that the usual description and delineation of the innominate bifurcation is incorrect. It is generally depicted as though the two branches arose side by side and almost at right angles to each other. In reality, the subclavian springs behind the carotid, and the angle between the two vessels is very acute; therefore, to detect the subclavian, the operator must place his finger at the back, outer aspect of the carotid, when, passing it down, he comes generally, a few lines above the clavicle, to the slightly divergent pulsating line of the subclavian, which lies deeper than the carotid by the whole diameter of that vessel.[3]

In selecting the spot for placing the ligature, it is well not to put it quite close to the bifurcation, but also not too near the border of the scaleni, lest the recurrent laryngeal or the phrenic nerve should be injured. The pneumogastric nerve and the jugular vein should be kept not too forcibly outward, and the needle should be passed from below, while with his left forefinger the surgeon gently presses the pleura downward and outward. Some obstruction behind the artery will very likely be encountered, but it is better patiently and gently to overcome this, and never on any account to attempt to pass the needle the other way; for if this be attempted, the point of the instrument is certain to penetrate the pleura.

Having now passed and tied the ligature, the surgeon should consider the advisability of also securing the vertebral artery. It lies in the groove between the longus colli and the scalenus, so that the jugular vein must now be held

[1] It may, by an operator sure of his hand, be cut freely.

[2] The mere division of the muscle is in itself unimportant, but there lies behind it a plexus of large veins, passing from the thyroid body to the internal jugular, generally distended by the dyspnœa accompanying aneurism at the root of the neck. Their division causes profuse bleeding, and subsequent difficulty in recognizing the deeper parts. This happened in both of Auvert's cases, while the fortunate knife of Colles missed a large vein just behind the muscle. Hayden, too, encountered severe bleeding when dividing the sterno-thyroid.

[3] In one case, owing to the depth of the vessel, Liston thought it might arise from the aorta to the left of the right carotid, and pass to the right scaleni behind the œsophagus. This, of course, may have been the condition of things, but, also, he may have been mistaken.

inward; the dissection already made will have so nearly exposed the artery, that a few touches with a director will lay it sufficiently bare to allow the passage of the needle. The position of the phrenic nerve on the anterior scalene muscle, outside and a good deal in front of the vessel, guards it against much risk of injury, but still it must be carefully avoided. The operator must not mistake the inferior thyroid branch (which is, however, much smaller, and usually at this part external) for the vertebral artery itself.[1]

*Deligation of the Innominate Artery.*—If it be intended to tie, not the subclavian, but the innominate, or if the former artery be found so diseased as to render deligation hazardous, the same incisions and dissection will suffice for passing a needle round the brachio-cephalic trunk. In most cases, however, it may be necessary to divide the round, sternal origin of the sterno-mastoid muscle, and in some the outer fibres of the sterno-thyroid. The surgeon's finger, passed down the carotid as above described, impinges on the innominate at its bifurcation, the only part which, without removal of bone, is attainable.[2] Unless, as sometimes happens, the innominate be shorter, that is, divide lower, than usual, its extreme end can be drawn up into the neck by throwing the head well back. If the respiratory difficulties of the patient prevent this, or a low bifurcation render it ineffectual, a device which I have had more than one occasion to use on the dead subject may be resorted to, unless the carotid is aneurismal or much diseased, namely, to gently grip that vessel in a pair of smooth jawed (non-serrated) forceps, and, by drawing it upward, lift the end of the artery from behind the sterno-clavicular joint. The fascia on each side of the vessel, that is, just below the subclavian, and inside and below the carotid, should be incised or torn to facilitate the passage of the needle. After tying the artery it will probably be safer, not merely as obviating distal hemorrhage, but for the future course of the aneurism, to tie the carotid also. The vertebral will probably lie behind the aneurismal sac; if not, that vessel also may be secured without enlarging the incision, or indeed adding to the danger of cerebral complication.

These operations are in all cases sufficiently arduous to demand from the surgeon all his coolness and skill; but when the aneurism lies over or very close to the part to be ligatured, when the disease displaces the vessel and changes its relations, when anatomical irregularity exists, all the difficulties become enormously enhanced.[3]

Deligation of the innominate artery, first performed by Valentine Mott, of New York, presents us with a ghastly list of deaths, every operation except one (Smyth, of New Orleans) having proved fatal, and by hemorrhage. Nevertheless, if we examine the events of each case, it is evident that this operation would not be necessarily fatal if a ligature were employed which, by leaving all the coats of the vessel entire, could not be followed by bleeding at the site of deligation. Mott's and Hall's patients walked about (most imprudently), one on the twenty-third, the other on the third day. If we except Bickersteth's case (temporary ligature), and Hutin's (not aneurismal, but a case of punctured wound), we find the patients living not a few hours only, but days, until, namely, that dangerous moment for silk and hemp, the time of separation of

[1] In certain cases, the aneurismal sac overlying the vertebral artery renders it inaccessible.

[2] Cooper (San Francisco), in a case of large aneurism, removed the upper part of the sternum and a portion of the clavicle; but when it is considered how frequently in thoracic aneurism part of the sac is formed by these bones, the danger of such a procedure will be evident; Cooper's patient lived thirty-four days.

[3] We find: pleura wounded, one case (Colles); severe bleeding from veins under sterno-thyroid, three cases; abnormal arteries divided, two cases; abandonment of operation on account of position of sac, four cases; while in one case (Liston) great difficulty was found in reaching the subclavian, which was supposed to arise from the aorta and to come into the right side of the neck behind the œsophagus.

the ligature, arrives. Sixty-seven and sixty-five days are the longest periods of life, but whether long or short, the mechanical action of insoluble ligatures—the severance of arterial coats—is the immediate cause of death.

To the record of completed cases, we must add four of abandoned operation. One surgeon finding the innominate too diseased, tied the carotid;[1] two other surgeons simply desisted; in one case (Key) complete, in another (Porter) partial solidification resulted from the manipulation, or from an inflammatory condition set up in the coats of the sac.

As regards hemorrhage and the insoluble ligature, the same remarks apply; all the recorded cases (except Smyth's) have proved fatal, but the necessity of such a mortality with a different form of ligature is very doubtful, and is at all events not proven.[2]

*Deligation of the Left Subclavian Artery in its First Part.*—If the operation of tying the first part of the *right* subclavian artery be difficult, the deligation of the *left* vessel is hazardous in the extreme; the artery on this side lies more deeply, passing into the neck out of the thorax from behind the lung, nor does it rise as high above the first rib: it is almost longitudinal in direction—the internal jugular vein and the vagus nerve are dangerously near and parallel to the vessel—while in front and on the inner side, and somewhat outside, is the pleura. Thus the deep incision, in which the work must be done, offers hardly any space, and when we add the possibility, even probability, that even this narrow area may be still further diminished by encroachment of the aneurismal sac, it will at once be understood that the operator must be bold and confident who would undertake such a task; nevertheless, the deligation has been effected once, by Dr. Kearney Rodgers, of New York,[3] whose description of the operation, as both instructive and monitory, may here be abridged.[4]

The external incision was the same as that above described for tying the right subclavian; the inner three-fourths of the sterno-mastoid muscle was divided.[5] On turning up the muscle, a portion of the aneurismal sac, strongly pulsating, was brought into view overlapping half the width of the scalenus. The fascia being torn, the deeper work had to be carried on between the aneurism on the outer, and the jugular vein on the inner side, aiming at the inner edge of the scalenus, half an inch above its origin, so as to avoid the thoracic duct; when this point was reached, the vessel was found without difficulty by pressing the finger downward. The needle with removable point was used to pass the ligature, "great care being necessary to detach the artery and to avoid danger to the pleura and thoracic duct." Very little immediate shock followed the operation. On the tenth day, a cough commenced; on the thirteenth, secondary hemorrhage set in, and the case terminated fatally on the sixteenth.

At the autopsy, "a large, irregular, lacerated opening was found in the pleura," and the cavity was filled with coagulated blood. "The artery had been completely divided by the ligature, which was found loose in the wound. The stump of the subclavian, between the aorta and ligature, presented the appearance of a round, solid cord, about one and a quarter inches long, impervious to water and air." Beyond the ligature, no plug other than a soft, quite recent clot, occupied the lumen of the artery; the vertebral was given off immediately at the point of ligature, and contained a like clot, evidently formed only just before death; the internal mammary, also, was patulous and healthy.

[1] Afterwards the subclavian was ligatured by A. B. Mott; see table of cases of consecutive double distal ligature.

[2] See Appendix to this Article, containing account of Mr. Thompson's case of innominate ligation with the ox-aorta ligature.

[3] Sir Astley Cooper tried to tie this vessel, but abandoned the attempt, believing that he had wounded the thoracic duct.

[4] The case is given at length in the New York Med. Journal, 1846.

[5] It is not stated what was done with the sterno-hyoid and sterno-thyroid muscles; they are simply mentioned as seen, covered by the fascia.

The complete division of the artery by the ligature, and the open state of the distal part of the vessel, require no further commentary than a reference to what is said at p. 443. The opening observed in the pleura shows that this membrane was probably wounded in spite of the surgeon's great care.

*Temporary compression or ligature* of the innominate has been resorted to by Mr. Porter, of Dublin,[1] and by Mr. Bickersteth, of Liverpool.[2] The former used his artery compressor—an instrument like two aneurism needles sliding one within the other, or like a minute lithotrite; the latter employed a somewhat complicated appliance, whereby he hoped to compress the artery by an elastic force connected by lead wires to the pressure-bar passed beneath the vessel. The former instrument failed by causing a slough of the artery; the latter by the giving way of one of the wires. Mr. Bickersteth then tied the vessel on each side of the part that had been compressed, with the usual result, secondary hemorrhage, beginning on the seventh day, recurring, and destroying the patient in twenty-four hours.[3]

*Deligation of the axillary artery for subclavian aneurism* has, as a distal operation, every possible defect, many vessels being given off by the diseased part of the artery, or between the sac and the ligature. The procedure has been employed five times, and in each instance certainly did no good, but probably hastened the fatal termination.

The next aneurismal tumor at the root of the neck, of which the treatment is to be considered in the order we are pursuing, is *low carotid aneurism*, by which words it is intended to indicate a tumor placed so low in the neck that a portion of it is situated below, on a level with, or just above the clavicle. This position offers the surgeon no opportunity to apply a ligature anywhere between the tumor and the heart, unless he have recourse to tying the innominate. Hence the treatment is restricted to a tract of vessel beyond the sac, to what are called distal methods. Distal pressure on the carotid is unpromising, because it has to be applied higher than Chassaignac's tubercle, at a point where the patient cannot possibly bear it for a sufficient length of time, if it be directed backwards. The only feasible method, therefore, is that practised by Rouge,[4] which has already been described (p. 497), as have also the possible advantages and very certain dangers of the rapid mode of employing compression. If rest and pressure fail, we have no recourse but to place a ligature round the carotid on the distal side of the aneurism.[5] This operation was first formulated and practised by Wardrop, who especially pointed out its applicability to the carotid, since no vessel is there given off between the ligature and the origin of the artery.

A *distal deligation of the carotid* should be practised above the omo-hyoid muscle, and not far from the bifurcation. The method of performance has already been described, but I would point out that an aneurism may considerably displace the vessel, and that care in studying the part and its vicinity should therefore in every case be used.

In this operation the pulsation of the aneurism does not cease, as in the proximal deligation. When the ligature is tightened, indeed, it may for a few seconds increase, but the tumor should not increase in size. Such an event would be of bad augury, as indicating danger of future rupture. Shortly after, a noticeable but not very great decrease in size can be verified,

[1] Dublin Quart. Journ. of Med. Science, Nov. 1867.

[2] Medico-Chirurg. Trans., vol. lvi. p. 129.

[3] I am not aware that the instrument of Dr. Fleet Speir has been used on this vessel. For remarks on temporary ligature, see p. 439.

[4] Rouge's case was cured in 136 hours—viz., 8 hours daily during 17 days.

[5] Neither electrolysis nor injection of coagulants is applicable, since cerebral embolism would almost certainly follow.

and slowly the pulsation diminishes. We have not sufficient experience to fix any date for its cessation; indeed, in certain cases, as when the aneurism is placed very low, pulsation may be communicated to the solidified tumor from the innominate on which it rests. I find but a few cases on record of this operation, for carotid aneurism pure and simple, and at least three of these terminated fatally.[1]

This paucity arises from the fact that low carotid disease, even though commencing simply in that vessel, has a great tendency to spread downward, and to encroach upon the end of the innominate; but chiefly because it is probable that most of the aneurisms developed in this place begin, as so many aneurisms do, at the point of bifurcation of the latter vessel. Of course an aneurism commencing at that part may spread upward on the carotid, laterally to the subclavian, or in both directions. They remain, however, high innominate aneurisms, although they are frequently called carotid or subclavian aneurisms, involving the innominate.

*Innominate aneurism*, when diet, rest, and medicine have failed, is hardly amenable to other form of surgical treatment than operative. The surgeon may, indeed, try galvano-puncture, the statistics of success and failure of which have already been given. Pressure, if used at all, can only be distal; nor can it be expected, as a rule, to yield any good result; yet the fact must not be overlooked, that one case of innominate aneurism is reported to have been cured, or greatly benefited, by this method.[2] The instrument used was a modification of Bourgery's compressor for subclavian aneurism, namely, a broad leather belt round the chest, bearing an oblique strap, which, fastening to the left side of the belt, back and front, passed over the right shoulder, and kept a pad firmly pressed on the subclavian. The corset carried behind a steel plate, bearing an upright rod, terminating above in an adjustable lever, with screws, pads, etc., whereby compression could be made on the carotid. The laryngeal symptoms and occasional faintings, previously distressing, disappeared in a week; at the end of three months the instrument was laid aside, and the patient returned to her usual household duties. The report was written ten months after treatment had been abandoned, the patient, if not cured, yet living her usual life. The means appear very inadequate to the end in view and to the success obtained; no doubt there must have been in the patient a great tendency to spontaneous cure. Still, the case is, as far as it goes, important, as showing the possibility, however remote, of aiding recovery by distal pressure.

The operative treatment of innominate aneurism has, of late years, greatly interested the surgical profession, many having attempted to realize Wardrop's views regarding distal ligature. It is unfortunate that that surgeon, in his well-known case (Mrs. Denmark's), should have erroneously supposed his patient's right carotid to be obliterated, so that he tied only the subclavian, in its third part. Even with this inadequate operation the patient was greatly benefited, but died two years after, a large aneurism of the innominate still persisting.

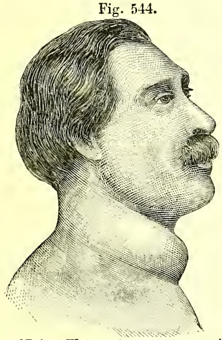
The method thus inaugurated, was repeated from time to time by other surgeons, with certain variations to be immediately described, but without

[1] My figures differ from those of both Dr. Wyeth and Mr. Holmes. The names of the operators are as follows: Wardrop, Bush, Lambert, Wood, Montgomery, Lane, and Colson (de Noyon). [Additional cases, raising the number to ten (with four deaths), are recorded by Demmé, Delens, and De Mello Ferrari; an eleventh case is attributed to Barbosa.] Like Mr. Holmes, I count but one case to Wardrop; the vessel in his other case bore on post-mortem examination no sign of having been tied. I add to each list certain other cases. Several cases diagnosed as examples of pure carotid aneurism have been afterwards proved to belong to a different category.

[2] A. M Edwards, Lancet, Jan. 9, 1858. The case appears to have been overlooked by most, if not all, writers on this subject. At least I do not find it quoted in any work that I have searched.

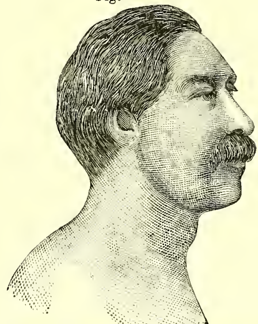
much success, until 1865, when Mr. Heath tied simultaneously the right carotid and subclavian for a woman supposed to be suffering from innominate aneurism,[1] who survived four years in spite of the most wretched, drunken habits. In 1872, an excellent study and *résumé* of the subject, by Mr. Holmes, kept up an interest which had never greatly flagged.[2] Nevertheless, no successful instance of this mode of treating innominate aneurism had occurred until August, 1877, when I tied simultaneously the right carotid and subclavian in the case of Robert Watson, illustrations of whose case, before and after the operation, I subjoin.[3]

Fig. 544.



Case of Robert Watson ; innominate aneurism.

Fig. 545.



Case of Robert Watson, seven weeks after operation.

In thus dealing with an aneurism of the innominate by attacking its branches, it is evident that a certain choice lies open to the surgeon. He may either elect to tie, at the same operation, the common carotid and the subclavian, third or first part, or he may ligature one of these vessels as a first step, reserving the other to some favorable opportunity. These procedures are called "double distal ligations," the former being qualified as "simultaneous," the latter as "consecutive." Or he may content himself with tying only one of the vessels in question, the one selected being usually the carotid, though in a few instances the subclavian only has been tied. Having then this wide choice, the surgeon requires certain grounds upon which to base his decision: first, as to the propriety of adopting any operative measure; and secondly, as to what that measure should be.

The former consideration is at the present day of very vast importance, because the method of double distal ligature has, of late years, received a great impetus; it is also one in which I am personally interested, as much of that impetus has been imparted by my own successes and writings. By the results of surgery in this department, during the next few years, posterity will judge the justifiable or unjustifiable nature of the procedure. Now success in great measure depends upon a judicious selection of cases; while want

[1] After death, the aneurism was found to have been aortic. The case is reported in the Lancet, Jan. 5, 1867 ; the preparation is in the College of Surgeons' Museum, Pathological Series, 1596 A.

[2] Lectures on the Surgical Treatment of Aneurism, delivered at the College of Surgeons, and published in the Lancet, 1871, 1872, 1873.

[3] By kind permission of the Council of the Medico-Chirurgical Society, in whose Transactions, vol. lxi. p. 32, the case is published. The aneurism was cured, but the man exposed himself, insufficiently clad, to most inclement weather, and died of bronchitis, quite independent of the original disease, six months afterwards.

of judgment or insufficient care in examination will most certainly bring a valuable operation into disrepute. For the guidance of the surgeon, I would submit the following aphorisms:—

I. An aneurism commencing suddenly, especially if traceable to some traumatism or over-exertion, is more likely to be benefited by operation than one arising gradually and without assignable, mechanical cause.

II. Distinct sacculation is a most desirable condition; fusiform dilatation of the innominate indicates almost certainly a similar condition of the aorta, and widespread arterial disease.

III. If symptoms show the aortic arch to be also affected, the disease should be limited, that is, should not extend along the transverse portion; it should be of the sacculated variety, not a general dilatation of the whole calibre. Absence of any other aneurism, especially of the rest of the aorta, must be ascertained.

IV. Absence of rasp-sound along the aorta, or any other indication of extensive atheroma, should be verified.

V. Aortic incompetence (obstruction, regurgitation, or both), unless very slight, is a decided objection, as is also mitral disease or considerable hypertrophy of the heart.

VI. Patency of the vessels leading to the brain should be investigated by making a few seconds' pressure on the carotids alternately, and then simultaneously.

VII. Absence of visceral disease must be ascertained.[1]

The choice of tying both vessels at the same time, or of at first securing one only, must depend in part on certain peculiarities of the aneurism, in part on other matters concerning the circulatory organs. In regard to this question I would offer the following rules:—

I. If the aneurism occupy the distal end of the innominate, with the root either of the carotid or of the subclavian, but not of both, then we may tie the one or the other respectively.

II. If there be only a moderate degree of aortic incompetence, such as might, however, be dangerous for simultaneous deligation, the surgeon must carefully consider whether its amount would also preclude tying a single vessel.

III. Aortic dilatation may be such in amount as would permit of tying one, but not both vessels, without danger.

IV. Any strong suspicion that the left carotid, or either vertebral, was blocked, would negative deligation of the right carotid, but not of the subclavian in its third part.

V. In all these contingencies, except the last, the value of a subsequent deligation of the other vessel must be gathered from the manner in which the first operation has been borne, the amount of good effected, and the changes produced in the direction of aneurismal growth.

VI. When none of the deterrent circumstances are present, and when the aneurism of the innominate does not markedly obtrude on one branch to the occlusion of the other, both vessels should be tied.

## Aneurism of Arch of Aorta.

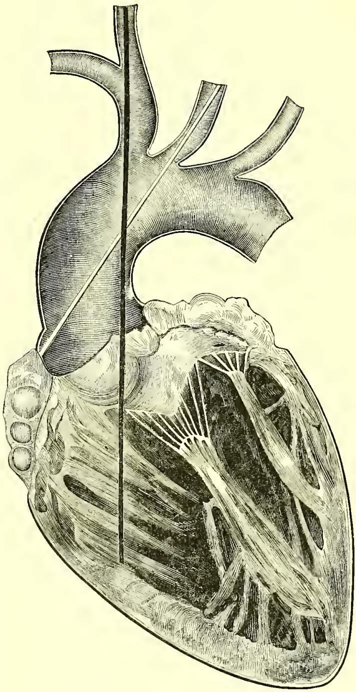
We now come to a subject, the surgical aspects of aortic-arch aneurism, which involves the latest developments of the surgery of vessels. In the

[1] Many a case has been placed on the debit side of the account when the aneurism had been cured, or was in process of cure, the patient having died of some other disease, the symptoms of which had been disregarded or overlooked. Some of these aphorisms may appear superfluous, but they are all justified by records.

year 1869, Dr. Cockle called attention[1] to several cases in which aneurism of the aorta had been cured, or greatly benefited, by obliteration of the left common carotid artery, whether by accidental impaction or by the surgeon's art, under the influence of a mistaken diagnosis;[2] and he recommended that in certain cases (which he did not very clearly define) of aortic disease, the left carotid should be tied in the neck. Shortly after, a suitable case presented itself, and under Dr. Cockle's supervision, Mr. Heath performed the operation. The practice has since been followed by Mr. Holmes and by myself, with incontestable benefit.

I was assiduously going through this whole subject, studying the results of operation and the causes of success or failure, when it appeared to me that Dr. Cockle's theory did not by any means exhaust the subject; and this idea was confirmed by considering cases of aortic aneurism, indubitably benefited, perhaps even cured, when the diagnosis had been incorrect, and when, under error, treatment had been directed to the innominate by tying vessels on the right side of the neck. This appeared to me connected with a curious fact in pathology. A concretion detached from an aortic valve almost invariably finds its way into the left carotid, occasionally into the left subclavian; into the right carotid about once in twenty-five cases. Hence it has been assumed that the left vessel lies more fully than the right in the axis of the ascending aorta. The very reverse is the fact, as may be proved by making a little puncture in each carotid just below its bifurcation, and passing long probes down both, as far as they will go, when, on removing the chest-wall and opening the aorta, the two probes will be seen crossing each other within the vessel. The right probe passes through the aortic opening not far from its left margin, and is well within the ventricle. The left probe strikes the tendinous ring of the aortic orifice on the right aspect of the vessel. In some bodies the end of the instrument will be just within the heart; in

Fig. 546.



Axes of heart, aorta, and carotids.

[1] Lancet, 1869, vol. i. pp. 422 and 489.
[2] See hereafter the cases of Montgomery, Tilanus, and Rigen; when error has been committed, the aneurism has been diagnosed as of the left carotid itself.

most it will be in the sinus of Valsalva. The probe is never in the axis of the aorta, but strikes the wall, be it of vessel or of ventricle, at a considerable angle.

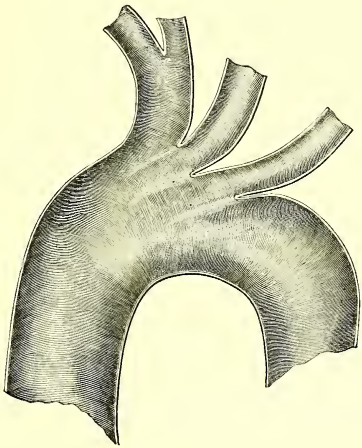
There must, therefore, be a truer anatomical cause for this propensity of detached concreta. Solids within a stream, if not too heavy, go with the strongest current; hence we may infer that some subtle curve or slope of surfaces directs the most potent rush of the stream obliquely athwart the vessel, towards the orifice of the left carotid. Looking at the position of parts, it appears highly probable that this is really so. For the axis of the left ventricle is not in a line with that of the first part of the aorta, but, if prolonged from the apex through the centre of the orifice, falls upon and about the outer sinus of Valsalva, whose concavity appears well calculated to divert and reflect the blood-stream in the direction indicated. In this course the current would pass from the right aspect of the aortic, obliquely towards the carotid orifice; it would occupy that portion of the trunk which in the diagram lies to the left of the whole probe (Fig. 546). Possibly the potent flow of blood in this direction is associated with the preponderance of the left brain and the right half of the body.

Another matter must be pointed out, namely, the anatomical arrangement whereby each vessel is enabled to divert and gather from the general current in the aorta, that portion of the stream necessary for the supply of its own channels and branches. First, we see the great brachio-cephalic trunk; then, be it observed, there is no interval between that and the left carotid. There is not, as is usually figured and imagined, between these two vessels a bit of transverse aorta, convex upward, but a mere angle, a sort of V-shaped double septum; a rather wider angle separates the left subclavian from the carotid. If the lower part of the ascending aorta be severed from the rest, and we look along the tube of the transverse part, we do not see the orifices of the carotid and subclavian foreshortened into ovals, or mere slits, as would be the case if these vessels were given off straight and plumb from the parent stem. On the contrary, these openings face us directly, so that we seem to see right into the lumen of each branch, and chiefly into that of the carotid.[1] This results from the mode of origin of these vessels. They are not given off straight and rectangularly from the transverse aorta, but their roots take a very oblique direction to the left, and then swerve more directly upwards; hence the distal margin of each vessel lies on a level considerably lower than the proximal. Each such margin has running from it, downward and to the right, on each side wall of the aorta, a rounded ridge, so arranged that the projection of the distal lip and twofold spur—in shape not unlike a half-funnel—catches the blood-stream as it courses along the main trunk, and directs each its own share into its special branch. The arrangement of these ridges is such that they divide all the upper aspect, and a considerable part of the side wall, of the aorta, into districts, one for each vessel. Hence an aneurism, unless it spring from the inferior, or concave wall, of the arch, must almost of necessity belong to the district of either one branch or the other (Fig. 547). In some bodies, however, the left carotid springs from the angle, as it were, between the aorta and innominate. In such instances,

[1] In my article in the Medico-Chirurgical Transactions, vol. lxii. p. 393 *et seq.*, being anxious to accentuate the absence of foreshortening, I said, "These openings look nearly round." The expression was infelicitous. Every careful anatomist knows that the openings are not round; their shape is different in different individuals. The general condition is that the innominate and subclavian openings are nearly semicircles, having their flat sides opposed at a considerable angle to each other, so that they are more widely separated in front than behind. In the wider part of this interval, and generally anterior to both the other orifices, is the opening of the left carotid, rhomboid in shape, and with its short end behind, so as pretty accurately to fit the above-described interval.

the ridge on the distal margin of the brachio-cephalic trunk is particularly strongly marked, and there is also a smaller ridge in the innominate itself, running from the proximal opening of the left carotid. In two dissections, I have found the left carotid arising altogether from the commencement of the

Fig. 547.



Arch of aorta and large branches, showing oblique roots of great vessels, and ridges running from orifices on aortic walls.

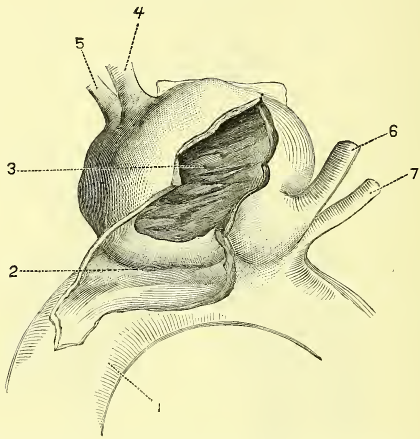
innominate. An aneurism of that vessel, occurring in such a subject, would give rise to some considerable embarrassment of diagnosis, and many doubts as to which point should be chosen as that to which surgical treatment should be directed. For instance, this was evidently the original state of the vessel in the aneurism here depicted; in the preparation, the peculiar anatomy of the left carotid can be more clearly made out than in the drawing (Fig. 548).

Now if these conclusions be correct; if there be in the aorta varying rates of current, and if there be districts of that vessel appertaining to the different branches, so that the blood which flows over or near any particular portion of its wall must pass into a given vessel, it follows that an aneurism in one situation, if amenable to surgery at all, must be treated from the vessels of the right side, while in other situations it must be attacked from the left.

Any special *résumé* of cases is impossible: my views were carried out, first, in my own case, and have since been followed by Dr. Lediard and Dr. Wyeth; these, as far as I know, are the only three cases in which double distal deligation has been knowingly undertaken for aortic aneurism. My patient lived fifteen months in fair health and comfort. Dr. Lediard's lived nearly ten months. Dr. Wyeth's died one year after the operation, from exhausting diarrhœa. That gentleman writes me: "Both arteries were obliterated at the points of deligation; they were not divided, but were

strong and fibrous, and the ligatures had disappeared. A gratifying and perfect success." The cases operated on under mistaken diagnoses have also done well in those instances in which the sac arose from the portions of the aorta about to be described, but badly when from elsewhere.

Fig. 548.




Aneurism of innominate, involving aorta and left carotid; 1, aorta; 2, wall of sac thrown down; 3, laminated clot lining aneurism; 4, right carotid; 5, right subclavian; 6, left carotid; 7, left subclavian.

We cannot then deny the possibility, and, if we could be certain of diagnosis, the high probability, of being able to benefit by operation some aortic aneurisms developed from certain definite regions of the arch. But to make his efforts valuable, the surgeon should be able to effect this, not merely in a few felicitous and fortuitous cases, while the less fortunate patients suffer injury; there should be in no case any haphazard element, but a clearly formulated view of what is to be done and what is to be gained. To attain such prescience, many difficult and minute problems in diagnosis must be solved.

The only forms of aortic aneurism with which surgery can cope, are the sacculated, and perhaps a few of such dilatations as occupy but a very limited and defined portion of the trunk. The former is more favorable than the latter form of disease. Fusiform enlargements, occupying a considerable length of the vessel, are not amenable to surgical treatment; nor indeed would I operate upon any case, whose symptoms did not permit of fairly clear and distinct definition of the place whence the aneurism arose. The method of doing this has not as yet been fully developed. Till of late years, when once an aortic aneurism had been detected, enough appeared to have been done; and even now many medical men do not think it needful to discriminate between tumors which spring from one, and those which arise from another part of the arch.

But the value which modern views on this subject have placed on more accurate diagnosis, will insure greater precision; and therefore symptoms, and

combinations of symptoms, which we may not as yet thoroughly understand, will prove to future investigators of much significance. Especially must this be the case in the early phases of the disease; the later stages, unless a history of the commencing phenomena furnish a clue, may still be undecipherable.

These points being premised, we may go on to consider the symptoms produced by aneurism of the aortic arch generally, and at first without reference to the order of their appearance.

(1) Tumor, pulsation, dulness, and certain sounds, depend upon the growth of an aneurismal sac from the artery, extending towards the surface, and displacing resonant lung by non-resonant blood (fluid or solidified). When the aneurism comes within a certain distance of the surface, the chest-wall protrudes, at first by mere bulging, but afterwards by a conical *tumor*, which visibly and sensibly *pulsates*. Around the point of strongest pulsation, a space of gradually diminishing impulse is traceable; so, too, *dulness* is in the middle of the space absolute, further out relative only, diminishing more and more until it merges into resonance; the dull area is usually continuous at one of its margins with cardiac dulness. Over the pulsatile enlargement, the *heart sounds* are heard with abnormal loudness, but the second sound is much more accentuated than the first; it is sometimes a dull, heavy thud, and in other cases a sharp, metallic ring, but it is always loud in proportion to the first sound, and even louder than over the heart itself. *Bruits* have hardly been mentioned hitherto, because their presence or absence is so variable; they are of different qualities and degrees, from a mere "coo" to a harsh, saw-like noise. Many cases run their whole course without any such abnormal sound; others are accompanied throughout by bruits; while in still a third series, the murmur—blowing or rasping—may be heard, either at the beginning or end of the case, while the intermediate portion of its course is marked by silence. These sounds, then, when present, are valuable symptoms, but their absence does not negative the existence of aneurism. We may group this whole range of phenomena under the term "tumor symptoms."

(2) Changes of the *pulse* are important, and are of different sorts. An artery may be partially obstructed by an aneurism springing from another vessel, curling over and pressing on its trunk; or, indeed, by a non-aneurismal tumor. The ambiguity which would arise from such a condition must be cleared away by examination of other symptoms. The direct influence of an aneurism on the pulse of the vessel from which it springs, is a reduction of the beat of the vessel below the tumor; it does not necessarily follow, though it is usually the case, that less blood finds its way along the tube, but it does so in a more even manner. A familiar, though not perfectly accurate, simile may be taken from the mechanism of a fire-engine (the heart), which delivers water along the hose (artery) in an even stream, although its force is imparted by alternate strokes of the pump. This is effected by letting the water first pass into a cavity—kettle I believe it is called—from which the hose issues. Now, the kettle contains at the top a little air, whose elasticity, acting as a spring, diminishes, if it does not quite eliminate the intermittent or pulsatile quality of the current. The aneurism has in it no air, but the widening of the channel at a point between the heart and the artery examined [together with the elasticity of the sac-wall] is sufficient to moderate, though it does not altogether suppress, the pulsatile character of the stream.

Thus, the sphygmographic trace shows a sloping and low upstroke, and an absence of tidal and dicrotic waves, so that, for instance, in an aneurism of the innominate, or of either subclavian, the line may represent a mere succession of even and shallow undulations. This is represented to the finger by a weak, full, soft pulse—indicating an artery which throbs slightly, never empties

itself, and, not having the stimulus of the expansile throb, does not contract fully. An aneurism situated less directly on the course of the artery examined, causes changes less easily described, because more varied—a less sloping upstroke, and all beyond represented by a zigzag line running down to the bottom of the next upstroke—and to the finger gives the sensation of a weak pulse, with a thrill or vibration.

(3) *Dyspnœa* and other *respiratory troubles* are among the most distressing symptoms of aneurism at the upper part of the chest and root of the neck; indeed, many cases of the disease prove fatal merely by obstruction of the air-passages. These troubles are of two kinds, produced, the one by direct pressure on the trachea, bronchi, or both, the other by interference with the recurrent laryngeal nerve. Nor are these forms difficult to distinguish from each other. The first produces dyspnœa from obstruction, and on applying a stethoscope to the chest, a peculiar, harsh, loud, bellows or organ-pipe sound, is heard, at first only on inspiration; afterwards, when the obstruction is more marked, the expiratory murmur is altered in a like manner. If the pressure be on the trachea, this sound is equal in both lungs; if it be on a bronchus, it will be very much more marked on one side than on the other. It is always heard on both sides, unless the point of partial occlusion be very low down, since the irregularities in the current of air affect the stream much above the actual seat of obstruction, though more slightly. Subsequently, if the bronchus become altogether closed, no sound—not even the respiratory murmur—is heard. These symptoms are continuous, but every now and then there arise severe paroxysms of violent efforts for breath; the chest heaves, the veins of the head and neck swell, the face becomes livid, a little air wheezes in and out, and severe, brassy cough adds to the distress until a little thick mucus is expectorated. The quieter phase is then restored until another mass of secreted material obstructs the already too narrow channel. With all this, the voice, unless in the exacerbation, is not particularly weakened; nay, sometimes it is rather loud and metallic.

The other form commences with changes in the voice, first of all in the tone, which is high, squeaky, and false—or whispering, with muffled falsetto. If dyspnœa occur at all, it does so early in the case, the symptoms resembling those of *laryngismus stridulus*.[1] It is under such circumstances also paroxysmal, but less frequent and more periodical than in the previously described variety. After an interval, aphonia, sometimes complete, sets in, and there may be considerable tendency to choking at meals, that is, to the food passing into the wind-pipe. Examination with the laryngoscope will show that the former condition depends upon tightness (spasm) of one vocal cord, rarely of both; the latter on paralysis.[2] In some cases the dyspnœa and violent cough (tracheal or bronchial symptoms) coexist with the laryngeal troubles.

(4) *Dysphagia* from pressure on the œsophagus is nearly always a later sign than tracheal or bronchial dyspnœa. The patient finds a difficulty in swallowing, at first solids, and afterwards even liquids. By listening a little on the left side of the last cervical or upper dorsal vertebræ, while the patient is swallowing a teaspoonful of water, a prolonged, reduplicated effort at deglutition will generally reveal, even before the patient is himself aware of it, obstruction in the gullet.

[1] Tracheotomy has been more than once performed.

[2] Dr. Bäumler and Dr. George Johnson showed specimens, in 1871 and 1872 respectively, in which, by the pressure of an aneurism, both vocal cords were paralyzed (Pathological Transactions, vol. xxiii. p. 66, and vol. xxiv. p. 42). In both cases, however, there must have been considerable pressure on the trachea itself (in the former only is it distinctly mentioned), and to this I would attribute the partial paralysis of the right laryngeal muscles, the nerves of which were not directly compressed by the sac. The fact that such tracheal obstruction can take place, must inculcate caution in the interpretation of this symptom.

(5) Another symptom is *irregularity of the pupils*, either dilatation or contraction, from irritation, and afterwards impeded function, of the sympathetic, and perhaps also of the vagus.

(6) *Displacement of the heart* downward and to the left, and certain pains in the depths and at the back of the chest, afford valuable though somewhat negative data for diagnosis.

(7) One of the most important symptoms is produced by pressure on the veins, causing *congestion* of different parts, often a *doughy lump* over one or both clavicles, and *œdema* about the face or arms. The significance of the localities of congestion depends in great measure upon their relation to other pressure symptoms. Certain combinations furnish remarkably positive evidence. For instance: pressure wholly and entirely on the right bronchus; congestion of both arms and both sides of the head and chest; tumor symptoms, chiefly about the second space and rib, considerably to the right of the sternum; heart displacement, if any, directly outward; the pulses equal, with very slight sphygmographic change—perhaps a rather sloping upstroke, usually a flat, blunt apex, absence partial or total of dicrotic wave, but undulatory character of whole down-line—indicate disease of the ascending aorta. Congestion of the left arm, supraclavicular region, and side of the head; aneurismal character of right pulse (radial and carotid); tumor symptoms a little to the right of the sternum, and probably some tracheal dyspnœa, are symptomatic of aorto-innominate aneurism. Modification of left radial pulse; affection of left vocal cord; left venous congestion; tracheal dyspnœa and obstruction of air to both lungs, with tumor symptoms on and to the left ot the median line, mark disease of the transverse aorta. Obstruction to the entrance of air to the left lung alone, with pains at the back and along the intercostals, is indicative of disease of the third part of the arch.

It is unnecessary to multiply these examples, which must be taken as indicating simply the broader lines of diagnosis.

*Treatment of Aneurisms of the Aortic Arch.*—A certain number of patients suffering from aortic-arch aneurism have undoubtedly got well under treatment by rest and medicines. These cases, however, are but few; the great majority of these patients either receive no benefit or quickly relapse. Hence every such case should be sedulously watched, that failure of treatment may at once be recognized. Especially should the commencement of pressure on the air-tubes be carefully observed, because increasing dyspnœa is not only a sign that the aneurism is becoming larger, but shows that the rest treatment is no longer possible. There can be no repose for one who is now and again convulsed with violent cough, and whose every breath is labor. Moreover, as my late lamented friend, Dr. Pearson Irvine, conclusively showed, partial occlusion of the windpipe brings on a certain form of pulmonary disease, chiefly due to obstruction in the exit of air.[1] This disease of itself would destroy life, even if the aneurism could be cured. Therefore any considerable difficulty of breathing should be a strong inducement to operation, unless the circumstances be unfavorable.

We should, however, have clear rules for guidance as to which cases will, and which will not, benefit by such treatment. Furthermore, we have to discriminate between the suitability of two operations, namely, that on the left, and that on the right side of the neck. In order, therefore, to save space and time, I will put in the form of a summary the conditions which should guide us in our choice. It must, of course, be understood that only the principal, not the minuter points, can be thus summarized, and that in

[1] Pathological Transactions, vol. xxviii. p. 67.

their combination certain of the symptoms may, especially if early in the case, be wanting.

(1) *For Deligation of Left Carotid.*—Tumor symptoms upon and somewhat, but not far, to the left of middle line, and rising into episternal notch, or beneath left sterno-mastoid. Left venous congestion; alteration of left carotid, and to a much less degree of left radial pulse. Paralysis of left vocal cord; obstruction to entrance of air, equal on both sides of chest; sometimes alteration of left pupil.[1]

(2) *For Deligation of Right Carotid and Subclavian.*—Tumor symptoms on right of median line. Marked changes in right radial and carotid pulse. Venous congestion on right side, affecting first and chiefly head and neck. Afterwards, with increase of tumor, right arm and chest, and right vocal cord, may be paralyzed.

Tumor symptoms on right of and upon mesial line, running up to sterno-clavicular joint and episternal notch; venous congestion on left side; alteration of right pulse (radial and carotid); tracheal dyspnœa.

Tumor further to the right, and lower (second space); congestion equal on both sides; no marked difference between the two pulses; heart displacement, chiefly outward.

Pressure on right bronchus; left lung perfectly free; with puerile respiration, and perhaps emphysema.

With any of these conditions, changes of the right pupil may be combined.

(3) *Doubtful Signs, only to be Read by the Light of other Symptoms.*—Venous congestion on the left side; tracheal dyspnœa; dysphagia.

(4) *Operation should be Avoided.*—When tumor symptoms reach widely on both sides of mesial line. When, with paralysis of left vocal cord, there is obstruction of right bronchus. When "locomotive" pulse, thrill, and double murmur, show considerable aortic incompetence. When there is mitral disease or considerable cardiac hypertrophy.[2] When there is, in the course of the aorta, the rasping sound of calcification or advanced atheroma, more particularly if the superficial vessels are felt to be rough and rigid. When there is pain about the spine and intercostal nerves; when there is obstruction of the left bronchus only; when there is pressure on the left apex, and expectoration of frothy blood. To these positive signs, I would add a negative one, viz., the symptoms being so indefinite as to render any diagnosis as to the site of the aneurism doubtful.

*Results of Simultaneous Double Distal Ligature.*—I have been restrained by considerations of space from giving, for the more usual deligations, the lists of operations, since tables of names, dates, results, etc., would in a work like this be inadmissible; but here, partly because the cases are comparatively few, partly to show the importance of the views which I have expressed concerning the conditions of the heart and aorta, the whole list, twenty-seven in number, shall be given in full. The first twenty-four cases were all of aneurism supposed to be innominate.

[1] I would carefully exclude such aneurisms as spring from the aorta beyond the orifice of the left carotid, as more likely to be injured than benefited by tying that vessel; whether any such cases could gain by deligation of the left subclavian, is doubtful, or has at all events not yet been proved.

[2] Aneurism of the aortic arch offers a certain resistance to the blood-stream, and thereby is rapidly productive of a certain cardiac hypertrophy. Unless this be severe, it need not negative operation if the valves be sound; a much smaller hypertrophy is deterrent if there be also aortic incompetence. Perhaps it will be well also to point out a circumstance which should induce us to insist strongly on operation, with as little delay as possible. Aneurisms of the ascending and cardiac part of the transverse aorta cause the mass of blood a little above the valves to be large in amount; hence it falls with undue force on the valves, which can be heard to close with violence—the door is slammed rather than shut. If this be allowed to go on, incompetence will soon be produced.

## Simultaneous Double Distal Ligature.

| No. | Surgeon. | Date. | Duration of life. | Termination. | Post-mortem appearances, and remarks. |
|---|---|---|---|---|---|
| | | | *For Innominate Aneurism (as diagnosed).* | | |
| 1 | Hobart,[1] | 1839 | 16 days | Killed herself by throwing pillow at nurse. | |
| 2 | Rossi,[2] | 1839 | 6th day | ...................... | Left carotid artery was closed; patient's brain nourished by one vertebral. |
| 3 | Heath, | 1865 | 4 yrs. 17 days | Aneurism practically cured. | It was of the ascending aorta. |
| 4 | Maunder, | 1867 | 5 days | Aneurism filled with soft black clot. | Tumor to left of innominate; left carotid should have been tied. |
| 5 | Sands, | 1868 | 13 mos. | Aneurism nearly full of laminated clot. | |
| 6 | Hodges, | 1868 | 12 days | ...................... | Merely an aortic dilatation. |
| 7 | Holmes, | 1871 | 55 days | No benefit. | Aorta much dilated. |
| 8 | Lane, | 1871 | 52 days | No benefit. | No post-mortem examination. |
| 9 | McCarthy, | 1872 | 15 days | Hemorrhage from proximal end of subclavian. | |
| 10 | Durham, | 1872 | 6th day | Death from shock. | Probably in this case cardiac hypertrophy. |
| 11 | Green, | 1874 | 3 mos. | Rupture of sac. | |
| 12 | Ensor, | 1875 | 65 days | ...................... | Aorta much dilated. |
| 13 | King, | 1876 | 111 days | Suppuration of sac. | Aorta much dilated. |
| 14 | Weir, | 1876 | 15 days | Sac nearly full of laminated clot. | Aorta much dilated, atheromatous. |
| 15 | Eliot, | 1876 | 26 days | Sac occluded by laminated clot. | Aorta very atheromatous. |
| 16 | Barwell, | 1877 | 103 days | Aneurism cured (patient killed himself by exposure). | Bronchitis unconnected with aneurism. |
| 17 | Barwell, | 1877 | 19 mos. | Aneurism cured. | Bronchitis, no connection with aneurism. |
| 18 | Barwell, | 1877 | 30 hours | ...................... | Aorta dilated; heart hypertrophied. |
| 19 | Little, | 1877 | 40 mos. | Aneurism cured. | Died from pleurisy, unconnected with aneurism. |
| 20 | Ransohoff, | 1879 | 7 days | Aneurism lined by laminated clot. | Fusiform dilatation, arch of aorta atheromatous, with calcification. |
| 21 | Stimson, | 1879 | Still lives | ...................... | |
| 22 | Palmer, | 1879 | 125 days | Aneurism consolidated. | Pressure of solidified aneurism caused ulcer of innominate vein. |
| 23 | King, | 1880 | 14 mos. | Aneurism cured. | Died from bronchitis; some aortic dilatation. |
| 24 | Pollock, | 1880 | 10 days | Aneurism lined with laminated clot. | Aorta dilated, and with large patches of atheroma. |
| | | | *For Aortic Aneurism (as diagnosed).* | | |
| 25 | Barwell, | 1879 | 15 mos. | Aneurism cured (ox aorta ligature). | Died from slow exhaustion and debility following dissipation. |
| 26 | Lediard, | 1880 | 8½ mos. | Aneurism solid (ox aorta ligature). | |
| 27 | Wyeth, | 1880 | 1 year. | Died from diarrhœa (ox aorta ligature). | Aneurism partly filled with clot death not due to aneurism. |

[The editor has, in his chapter on aneurism,[3] tabulated or referred to 33 cases of simultaneous, double, distal ligature, the aneurism in 23 cases having

[1] This is set down as a deligation of the first part of the subclavian. Mr. Holmes, who had an opportunity of examining the preparation, doubts if that vessel were tied.

[2] Some writer's report Rossi's case as a deligation of the first, others as one of the third part of the subclavian.

[3] Principles and Practice of Surgery, 3d ed. pp. 565 *et seq.* Philadelphia, 1882.

involved the innominate, and in 9 the aorta, while in 1 the aorta was dilated though not aneurismal; of the whole 33 cases, 17, or more than half, terminated fatally, while in 13 decided benefit, of greater or less duration, was experienced. The additional cases referred to by the editor are those of Browne (recovered), Denucé, and Marsh, and the fatal cases of Hutchison, Pollock, and Maury.]

It will be observed that in nearly all the cases of the above table which were followed by rapid death, the autopsy revealed disease of the heart, of the aorta, or of both. Therefore, the state of these parts should always be carefully investigated. In the present state of our knowledge, we may not always be able to diagnose atheroma of the aorta, or even a certain degree of dilatation; but it may often be inferred, though not absolutely made out. At all events, it is well to point out what conditions injuriously affect the death-rate of the operation, which should never be lightly undertaken without due knowledge of what to seek, and what circumstances should deter.

*Consecutive double deligation* has usually been employed in consequence of a hope that tying one of its branches would cure an innominate aneurism, the other branch being secured when, after a certain interval, improvement only, and not cure, has resulted. The operation may also, however, be undertaken because the surgeon, intending to tie both vessels, has reason, from the condition of the heart and aorta, to dread doing so simultaneously.

### Consecutive Double Distal Ligature.

*For Innominate Aneurism (as diagnosed).*

| Surgeon. | Carotid tied. | Subclavian tied. | Termination and post-mortem appearances. |
|---|---|---|---|
| Fearn, | Aug. 22, 1836 | Aug. 30, 1836 | Died of drunkenness, Nov. 27, 1838. |
| Wickham, | Sept. 25, 1839 | Dec. 3, 1839 | Died of rupture of sac, Dec. 15, 1839. |
| Malgaigne, | July, 1845 | Oct. 17, 1845 | Rupture of sac; erysipelas, Nov. 7, 1845. |
| Bickersteth, | May 11, 1864 | June 17, 1864 | No benefit; died of progressive disease, Sept. 1864. |
| Fleet Speir, | Constricted, May 4, 1874 | Tied, Aug. 6, 1874 | |
| Doughty and A. B. Mott, | 1875 | June, 1876 | Phthisis. Aneurism apparently cured, 1879. |
| Kuster,[1] | May 30, 1879 | Aug. 15, 1879 | Mitral incompetence; dilated aorta, Aug. 30, 1879. |
| Adams and Treves, | June 30, 1880 | July 2, 1880 | Hemorrhage from site of deligation. |

The result of tying the *right carotid alone* for innominate aneurism is not to be considered satisfactory, and more especially is it unsuccessful if the disease involve the aorta. The vessel has been ligatured for *innominate*, or supposed aorto-innominate, disease, thirty times, with twenty deaths. But in cases of *aortic*, or aorto-innominate disease, the operation has been performed seven times, and in only one instance has it proved beneficial—the case of Mr. Annandale.[2] With this exception, the longest survival was forty-one hours; the next, nineteen hours; the others, ten hours and under. The conclusion to be drawn, is, that for low innominate aneurism, which almost always involves the aorta, it is safer to tie both vessels than the carotid alone.

*Distal ligature of the right subclavian in its third part*, for *innominate aneurism*, would not appear a hopeful procedure, since the carotid and so many

[1] The patient was greatly relieved of pain, and asked, if it returned, whether the surgeon could not tie some other artery; there were, however, other aneurisms, one of which seems to have burst.

[2] The patient survived two years; the cause of death is unknown, and there was no post-mortem examination. (Letter from Mr. Annandale.) I cannot persuade myself that the aneurism was aortic; the immediate effect of the ligature—stoppage of pulsation—must surely negative such an idea.

subclavian branches must allow a large stream through the artery. It has been done twice under the mistaken idea that the carotid was already obliterated (Wardrop, Broca), and once purposely (Bryant). All the patients survived some time, and appear to have been to a certain extent benefited. [Blackman's and Laugier's cases (the latter a deligation of the axillary) both proved fatal.]

For *aneurism of the aortic arch*, the *left carotid* has been tied eleven times; in the first few cases, the disease was supposed to be of the carotid,[1] but the operation has since been performed by others,[2] with the direct intention of benefiting an aortic aneurism. The four cases of mistaken diagnosis, and the first three of the intentional operations, did well. Pirogoff thus operated on a woman with aorto-innominate aneurism—not the procedure to be selected; Küster, on a man who had fusiform aneurism of the aorta and extreme cardiac hypertrophy.[3] I have thus operated twice. My first patient was greatly improved, but died four months after of visceral disease. The next operation was undertaken at the desire of a physician, somewhat against my convictions; both carotid and subclavian were tied, as the aneurism extended far to the left. The man was rapidly approaching death when the vessels were tied, and I do not think that the end was either hastened or postponed.[4] Mr. Heath has also operated twice; his second case was unfortunate, the patient dying very quickly from syncope.

Thus of the eleven cases, seven did remarkably well; four badly; probably all four—certainly two of them—were ill chosen.

[The editor has tabulated[5] thirteen cases, including one of his own, of carotid ligation for aortic aneurism, more or less relief having been obtained in six.]

## Arterio-Venous Aneurism.[6]

A few words must be said concerning a form of disease involving not only the arterial trunk, but also the neighboring vein, or an adjacent venous cavity, which indeed essentially consists of an interparietal communication between the area of the one and of the other.

In former times, when venesection was so frequently practised as often to be entrusted to unskilful hands, this disease was very common at the bend of the elbow, and indeed, since other external aneurisms were treated after one method, that of Antyllus, the ingenuity of the older surgeons was chiefly exercised upon this condition. Anel himself, whose name is still attached to one form of arterial deligation, first practised his method on an aneurism of this sort at the bend of the elbow (see p. 433). But as we shall see, the disease may be spontaneous, and is by no means confined to this situation, but may occur in any part of the body where an artery and a vein are in juxtaposition.[7]

The disease assumes two forms, viz., *aneurismal varix*, when the artery opens directly into the vein, the edges of the two holes being in contact, and adherent; and *varicose aneurism* when between the two vessels is interposed a distinct sac, into which they both open.

[1] Montgomery, O'Shaughnessy, Rigen, Tilanus. It was these cases that prompted Dr. Cockle's paper and suggestion; Heath was the first to carry it into effect.

[2] Heath, Holmes, Barwell, Pirogoff, and Küster.

[3] Das Herz war ungemein gross.

[4] Med.-Chir. Trans., vol. lxiv.

[5] Op. cit., p. 565.

[6] That form of arterio-venous disease which consists in an enlargement of the arterioles and venules—viz., aneurism by anastomosis or cirsoid aneurism—has been described in the preceding article.

[7] Usually, the communication is formed between vessels that are normally in contact; but even this is not essential.

Aneurismal Varix.—The former of these maladies, nearly always traumatic, may probably best be described by taking as our type the formerly common arterio-venous puncture in venesection. "When this happens," says W. Hunter,[1] the first who correctly described this condition, "the injury done to the artery is commonly known by the jerking impetuosity of the stream which flows from the vein, and by the difficulty of stopping it when a sufficient quantity has been drawn;" also, if what I saw long ago in a single case be usual, by the appearance of two colors in the blood. When, however, the hemorrhage has been checked by pressure, and the wound has healed, the opposed openings adhere to each other, and the vessels intercommunicate. The disease is then marked by dilatation of the punctured vein and its affluents, for two inches or rather less, above, and for rather more than that distance below, the cicatrix left by the puncture. The enlargement is well marked; its limits are somewhat abrupt; it pulsates rather less forcibly than an artery dilated to an equal size would do; and added to this, there is a continuous, vibratile thrill, best felt when the finger touches the part but very lightly. To an ear applied gently on the tumor, this thrill is translated into a rasping or snarling sound, which William Hunter[2] compares to "what is produced in the mouth by continuing the sound of the letter R in a whisper." I would call it "thrill-murmur." This vibration is, if the hole of communication be large, apparent even to sight; especially at a point opposite the arterial opening. The venous tumor can be readily emptied by pressure, but immediately fills again, not by afflux of blood from the veins below, but from the artery above, as may be proved by tying a fillet tightly round the arm just under the seat of disease. When the limb is raised vertically, the tumor diminishes, and if, while that posture is maintained, pressure be made on the artery above, all thrill and bruit cease, while the swelling almost entirely disappears. In some cases the point of the finger, by following as a clue the line of most marked vibration, may be made to impinge directly on the arterial opening, when vibration is checked, and the enlargement almost entirely subsides.

Occasionally the artery above is dilated and convoluted, pulsating more largely and strongly than natural, while nevertheless the artery below, and the radial pulse on that side, are smaller than on the other. The veins, for a little way above, and throughout the limb below, are enlarged, tortuous, and varicose, and for a certain distance may be seen, or by a very light touch may be felt, to pulsate very distinctly. Also, in most cases, the integuments of the forearm and their appendices, hair and nails, are hypertrophied, and sometimes the part, especially in the course of the veins, is peculiarly hirsute.

Varicose Aneurism.—Varicose aneurism differs from the above-described condition by the interposition of a blood-containing cavity between the arterial and venous wound; the intercommunication of the vessels is, therefore, less direct, and hence a certain difference exists in the relative intensity of some of the symptoms above described, according to the indirectness of the obstruction, and the mode in which the two opposing streams meet within the aneurismal pouch. The veins, varicose both above and below, are not, as a rule, as largely distended immediately opposite the puncture, nor do they pulsate as distinctly and clearly, as in the other form of the disease. The aneurismal tumor is easily distinguishable; it pulsates and makes a peculiar noise, more or less loud and harsh according to the size, shape, and relative position of the openings. It is sometimes hissing or rasping, sometimes like the murmur of a spiral shell, the boiling of a kettle, or, as in a case which I

[1] Med. Observations and Inquiries, 1761, p. 34.

[2] Op. cit., p. 37.

saw in 1872, is like the noise of a gas-burner turned too high. It is sometimes loud enough to keep the patient awake, or even to waken him if he happen to raise up the affected arm near to his ear. The same mechanism which produces the sound causes a vibration of the tumor, which is exactly like the sensation communicated to a hand placed on the back of a growling dog, or a purring cat. This thrill is continuous, and may be felt through and with the pulsation, but neither increases nor decreases with the beat of the heart. The same condition of tegumentary hypertrophy exists as was described in speaking of aneurismal varix, and to this is not unfrequently added a general, soft thickening of the sort sometimes called solid œdema; ordinary œdema, also, is not unusual.

Other places where traumatism occasionally produces arterio-venous aneurism of the varix variety, are some parts of the scalp, mostly over the temporal, large auricular, and occipital arteries; but in those places, because the vessels are smaller, the anastomoses freer, and the surrounding tissues denser, a somewhat different result is produced, namely dilatation of the arterial and venous branches, their offsets and minute twigs, into a mesh of enlarged, convoluted, and pulsating vessels, closely resembling—indeed, generally indistinguishable from—cirsoid aneurism; a subject which has been considered in a previous article. Also, the disease has been known to follow fractures through the sella turcica or orbit, the preternatural communication being either between the carotid artery and cavernous sinus, or between the ophthalmic artery and vein, whence, as already described, originates one form of the disease termed pulsating tumor of the orbit.[1]

It must not, however, be supposed that arterio-venous aneurism is always the result of wound. Varicose aneurism has often occurred without such causation, and in deep parts of the body; even aneurismal varix may thus arise without direct wound. I believe Mr. Syme[2] to have been the first surgeon who published a case of varicose aneurism of the aorta. Six years subsequently, viz., in 1837, Mr. G. H. Perry[3] noted a case of this disease occurring between the popliteal artery and vein, and Mr. Porter[4] recorded a similar example. In 1840, Mr. Thurnam[5] read his excellent memoir on the subject; since which time, although additional cases have been published by Rokitansky,[6] Mayn,[7] Beaumont,[8] Pemberton,[9] Wade,[10] and many others, little light has remained to be thrown upon the matter. This light chiefly touches certain points regarding the relative frequency of the disease at different parts, and the mode of its occurrence.

Mr. Thurnam's paper first called attention to the fact that these preternatural communications may take place between the largest vessels of the body—as between the first or second part of the thoracic aorta and any large vein or venous chamber of the heart. Thus there is distinct anatomical evidence of the existence of arterio-venous aneurisms of most of the larger vessels of the body. Thurnam's cases, indeed, show that of 18 aortic aneurisms,

[1] Delens, Thèse; De la communication de la Carotide interne et du Sinus caverneux. Paris, 1870.

[2] Edinburgh Medical and Surgical Journal, July, 1831, p. 114.

[3] Medico-Chirurgical Transactions, vol. xx. p. 31.

[4] Cyclopædia of Anatomy and Physiology, vol. i. p. 242.

[5] On Aneurisms, especially Spontaneous Varicose Aneurisms of the Ascending Aorta. Medico-Chirurgical Transactions, vol. xxiii. p. 323.

[6] Ueber einige der wichtigsten Krankheiten der Arterien.

[7] Dublin Medical Journal, July, 1854.

[8] Medical Times and Gazette, 1867, vol. ii. The preparation is in the College of Surgeons' Museum.

[9] Medico-Chirurgical Transactions, vol. xliv. p. 189. The disease followed pressure-treatment for popliteal aneurism.

[10] Ibid., p. 211.

11 had formed communication with the pulmonary vein, 4 with a cavity of the heart, and 3 with one of the venæ cavæ.

Thus, on examining these records and collating them with others gathered by Sibson and by myself, we may construct the following table,[1] showing the relative frequency of these various conditions:—

| No. of Cases. | Aneurismal Artery. | Communicating with |
|---|---|---|
| 17 | Ascending aorta. | Pulmonary artery. |
| 6 | " " | Right auricle. |
| 3 | " " | Right ventricle. |
| 4 | " " | Descending vena cava. |
| 3 | " " | Left ventricle. |
| 2 | Transverse aorta. | Descending vena cava. |
| 7 | Descending aorta. | Ascending vena cava. |
| 5 | Common carotid artery. | Internal jugular vein. |
| 1 | External " " | " " " |
| 4 | Internal carotid " | Cavernous sinus. |
| 2 | External iliac artery. | External iliac vein. |
| 3 | Femoral artery. | Femoral vein. |
| 2 | Popliteal artery. | Popliteal vein. |
| 1 | Posterior tibial artery. | Posterior tibial vein. |

In five of these sixty cases, the form of intercommunication was that of aneurismal varix; in the rest, that of varicose aneurism. The mode in which the disease is produced in the large internal vessels, and frequently in external parts, is as follows: First the artery develops an aneurism which, in the course of its growth, presses upon and ultimately opens into a vein or venous cavity, just as it might, if otherwise placed, have opened into a bronchus or the pharynx. Sometimes such a rupture is followed by rapid or immediate death. Of the patients whose cases are above tabulated, though one lived for only a very few hours after the event, the larger number survived for weeks or months, and one even for more than three and a half years.[2] That life could be thus compatible with so grave a lesion, would be, unless supported by ample evidence, incredible; yet, not only does clinical observation indicate this fact, but the smooth and rounded margin of the arterio-venous opening attests the long duration of patency. Indeed, in one case the condition diagnosed during life caused so little trouble that the man "declared he was quite well, except that his breathing was a little short; he could not be induced to remain longer in hospital, as he was determined to resume his employment."[3]

The mode in which these openings form is the same as of any ruptures of aneurismal sacs into other adjacent cavities. The tumor in its increase presses on the walls of the venous space, causing adhesion, and then gradual thinning and absorption of the walls, until the sac bulges into the vein or cavity, and at this part—since an empty cavity or one with fluid contents offers less resistance than solid tissue—the wall is apt to further dilate and become thinner. The actual rupture may be aided by some sudden effort, or may be quite spontaneous; in the latter case it is more likely to be slower than in the former, but may be as sudden; and although one would suppose that sudden rupture must of necessity be more constantly and rapidly fatal than the more gradual breach, yet I do not find, as far as clinical symptoms permit the moment of the event to be fixed, that such difference really exists.

[1] I am, of course, aware that more cases are scattered, and especially of late years, in surgical journals, but it seemes to me sufficient to take those which I have found recorded between 1840 and 1870.

[2] Case VIII. of Thurnam. The communication was with the pulmonary artery.

[3] Wade, loc. cit. The communication was at that time only with the pulmonary artery, the opening into which was, after death, found to be round, regular, and smooth; a further opening, ragged and thin-edged, was recent, and the immediate cause of death.

External arterio-venous aneurisms may form in the same way, or from an abscess opening into both vessels; but this mode of origin is undoubtedly less frequent than some form of traumatism,[1] and especially common are, first, venesection wounds, and then gunshot injuries. Bardeleben collected from published sources 91 cases of traumatic anterio-venous aneurism. Of these 49 were from venesection, 14 from gunshot wound, and the rest from various forms of injury; therefore, as might be supposed, the greater number of cases depend upon preternatural communication between the brachial artery and the median basilic vein. The next most frequent seat of the disease is between the femoral artery and its vein (13 cases), the next in the temporal artery (9 cases),[2] etc.

Nor are we to suppose that the disease follows, of necessity, immediately or rapidly after infliction of the injury. In Rokitansky's case,[3] the disease first made its presence known in the axilla thirty years after the receipt of a gunshot wound. Beaumont's (Toronto) patient had received a wound in the groin; for more than ten years a loud and constant thrill-murmur, audible at some distance, was the only symptom; at the end of that time an aneurism formed while riding on horseback.[4] In Dr. Cotter's case, a wound of the thigh occurred eight and a half years previous to the formation in the scar of an aneurismal varix.[5]

That comparatively small vessels may be thus affected, is shown by the relatively not infrequent occurrence of a communication between the temporal artery and its companion vein; this has been generally due to arteriotomy practised for therapeutic purposes, but it has also followed an accidental wound. But perhaps the most interesting example of such disease in a very small vessel is the case reported by Mr. Moore.[6] The disease was developed on a branch of the sciatic artery within the substance of the popliteal nerve; therefore, though the tumor was not large, and communicated with very small vessels, it gave great pain, and caused considerable embarrassment in diagnosis. It is not mentioned, whether or no, in this case, auscultation was employed. The case is described as one of arterio-venous cyst.

*Diagnosis of Arterio-Venous Aneurism.*—The diagnosis of this disease, in those parts of the body which interest us as surgeons, depends upon the points of symptomatology and history already described. A direct wound in the course of an artery, followed by pulsation of enlarged and varicose veins; a tumor at or near the site of injury; and a murmur more or less loud and harsh, present the problem in its simplest and easiest form. When the vessel is superficial, as at the bend of the elbow, or near the groin, the distinctive differences between aneurismal varix and varicose aneurism can be readily made out. Certain symptoms may, it is true, either by their presence or absence, cause some doubts; but the peculiar purring, or thrill-murmur, is, when present, so characteristic, that, even if there be no tumor, the existence of arterio-venous communication may be taken as established.

More deeply seated disease, especially if it be surrounded and compressed by firm, strong muscles, occasionally, though rarely, omits the most significant symptom—murmur[7]—or, at least, that phenomenon may be but slightly marked.

[1] Pressure, as in Pemberton's case already mentioned, may be classed as a traumatic cause, although the mechanical injury be slow (chronic) in its mode of action.

[2] Bardeleben, Diss. Inaug., Berlin. Ueber das traumatische Aneurysma arterio-venosum.

[3] Ueber einige der wichtigsten Krankheiten der Arterien.

[4] Med. Times and Gazette, July 27, 1867.

[5] American Journal of the Medical Sciences, vol. xlviii. p. 36.

[6] Med.-Chir. Transactions, vol. xlix. p. 29.

[7] See a case by Mr. Annandale, Lancet, April 24, 1875. The disease was in the posterior tibial artery and companion vein, and was, until operated on, mistaken for a common aneurism.

On the other hand, if the vessel be one of the smaller branches of the scalp, dilatation of its offsets and of all inosculating twigs may cause the disease to assume the characters of cirsoid aneurism rather than that of direct communication, though in nearly all such cases the thrill-murmur is quantitatively different from the slight, rustling bruit of ordinary, large angeiomata. Again, from the cases already quoted, it is evident that murmur may, for a time, be the only symptom of the disease, which must surely have been present, though inactive, during the ten and the eight and a half years of abeyance of Beaumont's and Cotter's cases.

*Treatment of Arterio-Venous Aneurism.*—The treatment of this condition must be on the lines, slightly modified, of that of common, sacculated aneurism, but certain of the methods applicable to that affection are, as a rule, useless in this complicated form of the disease. Moreover, certain differences exist as to the management of the varicose and varix varieties.

In *varicose aneurism*, treatment is always necessary, while many cases of aneurismal varix, especially of the upper extremity, producing no pain, and not leading to rupture and hemorrhage, may be left untreated, or be simply met with palliative measures. Fortunately, also, varicose aneurism is somewhat more amenable than the other form to non-operative measures, namely, to the various forms of *pressure*. The presence of a sac in these cases is the point of vantage accorded to that form of treatment, and, indeed, it is probable that Reid's method—the elastic bandage being applied both below and above, but not over, the tumor—would be that most adapted to the exigencies of the case.[1] In the event of that mode of treatment failing, direct and indirect pressure should be given a full and fair trial, and in most cases it will be better to alternate these methods, according to the pain produced and the susceptibility of the patient. Even if the aneurism itself be not cured by these means, it may, perhaps, be converted into a simple aneurism by closure of the venous opening. Nélaton[2] records four cases in which this transformation took place, but it is somewhat singular that no such change has occurred in the practice of any other surgeon; Nélaton's patients were, it appears, afterwards cured, some by indirect pressure, some by the Hunterian ligature.

*Injection of perchloride of iron* has been employed, and in two cases with success—once, namely, by coagulation, and once by suppuration of the sac.[3] When, however, the precautions which must be taken during the treatment of simple aneurism by this method are considered, it certainly seems to me that the double communication of the sac of a varicose aneurism must render still more pressing the danger of embolism, unless, indeed, the blood in the whole limb be entirely immobilized for an unusually long time. The same remark may apply to *galvano-puncture;* yet three cases, two quoted by Ciniselli and one recorded by Debout, are said to have been thus cured.

The *ligature* for varicose aneurism is not to be lightly employed, but is most certainly justifiable when the tumor is increasing quickly enough to render rupture a mere question of time, or when pressure on other veins, besides that immediately implicated, renders gangrene a more probable result of delay than of interference. Cases, moreover, in which expectant or temporizing treatment can be adopted, are rare, though less so in the upper than in the lower limb. The Hunterian deligation must be rejected; it almost

[1] I have not myself had, since the introduction of this method, any opportunity of treating a varicose aneurism, nor can I find any record of a case so treated; the above opinion must, therefore, be taken as formed on *a priori* grounds only.

[2] Journal de Médecine et de Chirurgie pratiques, 2e s., t. xxxiii. p. 155.

[3] Jobert (de Lamballe), Bulletin de l'Académie de Médecine, 1854; Vallette, ibid., 1859.

always fails to cure, though a few cases are on record in which it produced a certain benefit[1] by delaying the progress of the malady. The form of deligation should be after the method of Antyllus, that is, immediately above and below the site of disease. Generally, in such cases, it will be necessary to open the sac and turn out any clots, little in quantity and loose in texture as they are in this form of aneurism; or, when feasible, greater safety may be insured by tying the vessel above and below, while leaving the sac intact. But certain difficulties attend this operation; if the vessel be not very deep, the upper part of the artery is reached with ease; but that part which lies below the tumor—contracted and often very small, surrounded also by swollen and tortuous veins—can with difficulty be found, and perhaps can only be taken up by tearing or cutting through many of those vessels. Herein lies one, perhaps the chief, danger of ligature for varicose aneurism, namely, the interference with and probable ligature of the main veins, which, in a limb already weakened and predisposed to sphacelus by the varicose condition of those vessels, may lead to rapid gangrene, especially if the disease be of the lower extremity. Hence in some cases, more particularly in old or enfeebled persons, the safer and more prudent course will be to amputate, rather than to incur the risk of producing an inevitable and perhaps irrestrainable gangrene.

The treatment of *aneurismal varix* should also be commenced by *pressure*, but direct pressure, not merely on the tumor, but also upon the foramen of communication, is that which is most likely to prove successful. Moreover, the finger has proved of all compressing instruments the most efficacious; yet it is only right to observe that in a large number of cases the treatment ends in disappointment. Nor does it seem desirable to continue it for any lengthened period unless palpable improvement gives encouragement to further effort. The Esmarch bandage and cord, if care be taken to keep the vessels at the site of disease full, also seem likely to be of avail.

If this simpler treatment fail, the circumstances of the case must be well considered before recommending any more severe measures. Frequently, and more especially in the upper limb, an aneurismal varix, having culminated in a certain enlargement of the vein about the site of disease, and in a certain varicose condition of the veins lower down, together with some weakness or facile fatigue of the part, proceeds no further, and remains stationary for years. In such circumstances, prudence would counsel both surgeon and patient not to employ, for a malady which involves so little inconvenience, any treatment that might endanger either life or limb. When, however, the troubles become, or in other cases are *ab initio*, more severe, and especially if they are increasing, surgical interference becomes not merely justifiable but imperative. *Galvano-puncture* and the *injection of coagulants* are not likely to prove of any avail.[2] There is no sac to the aneurism, but merely two tubes, one being more or less dilated; hence blood loosely coagulated by either method would probably be washed onward and cause embolism, as soon as the restraining pressure was removed. Both methods are probably more dangerous than in sacculated aneurism.

More safe is *deligation* with a properly selected ligature. The vessel should

[1] See case by Czerny (Archiv für pathologische Anatomie und Physiologie, Bd. 62, S. 464); the disease was femoral; the Hunterian ligature produced a certain temporary benefit. Also one by Ambrogio Gherini, who tied with slight transitory benefit the brachial artery at the junction of its middle and lower thirds, for varicose aneurism following venesection at the bend of the elbow (Annali Univers. di Med., Novembre, 1873).

[2] The latter mode of treatment has been recommended by a high authority as likely to be useful; but the opinion is not founded on any practical experience. (Holmes's System of Surgery, vol. iii. p. 531.)

be tied above and below the place of opening. The vein—especially if an important one, as the femoral at the groin—ought to be spared, though sometimes it is so adherent to the artery as to be barely separable;[1] yet to tie it would be very likely to induce gangrene. I would strongly advise very careful and patient attempts at separation to be made. It is below rather than above the opening that the difficulty occurs, and at the same time the artery is here so diminished in size that it is not easily found. Under these circumstances, and unless the diseased spot be immediately above a large branch, it may be well to relinquish the attempt to tie the artery below the mouth of intercommunication, and to elevate the limb. Blood from the vein could not, under such circumstances, flow along the artery, and in the absence of any arterial branch very near to the spot, return blood from the artery could hardly get into the vein. The Hunterian mode of deligation, whenever it has been tried under these circumstances, has, as far as I can find, invariably failed.

## Appendix.

Although this article was finished some time ago, it appears to me desirable to render it complete by inserting a case of deligation of the innominate artery, recently performed by Mr. William Thomson, of Dublin. I do this with the more pleasure since the case, although terminating fatally, proves that my views concerning the action and importance of a flat ligature are correct. It also illustrates the value of the needle depicted at p. 476, which was devised by me for facilitating the passage of a ligature under the subclavian and innominate. As will be seen on perusal of the case, the operation could hardly have been completed without its aid.

In March of the present year (1882) Mr. Thomson wrote to me, describing a case of right subclavian aneurism which was under his care, and saying that he proposed tying either the subclavian in its first part, or the innominate. He asked me for a piece of my ox-aorta ligature. I replied immediately by sending what he had requested, and my needle. As the patient dallied a good deal, sometimes accepting, sometimes declining Mr. Thomson's proposal, that gentleman returned the instrument, believing that the patient would not submit to an operation. However, at the beginning of June, I again heard from Mr. Thomson, and in pursuance of his request once more sent him the needle. He had preserved the ox-aorta ligature forwarded to him in March. The patient having finally determined to undergo the necessary treatment, I am able, by the great courtesy of Mr. Thomson, to give the details of the case in that eminent surgeon's own words:—

John Murphy, aged 49, a locksmith, was admitted to the Richmond Surgical Hospital, Dublin, on the 7th of February, 1882, suffering from aneurism of the right subclavian artery. He was a man of medium development, healthy looking, and of dark complexion. His hair was grizzled. He had never had syphilis, had lived a fairly temperate life, and had been for eighteen months in America, where, in the war with the Confederate States, he had received a bayonet wound over the right scapula. For two years and a half he had been suffering from pains in the right arm, which he thought were due to rheumatism; but ten months before his admission he first noticed a small tumor, "about as large as a marble," in the posterior inferior triangle of the

[1] When treating of deligation of the femoral artery, I pointed out that occasionally the femoral vein, or a vein close to it, had in this operation been wounded, and yet that when the artery had been tied, bleeding had ceased. If in endeavoring to isolate the artery venous bleeding from the enlarged vein should occur, I would recommend that this should not be immediately ligatured. When the artery has been secured, the effect of thus checking the flow of blood to the part, and of raising the limb above the level of the pelvis, should be tried.

neck. He had sought advice at another dispensary, and at our own, but he had refused to come into hospital until he found that the tumor was steadily progressing, and that in addition to increase of pain he was now unable to work. The tumor, as it now presented itself, was globular and about two and a half inches in diameter, pulsating violently, with evidently very thin walls. It occupied the posterior inferior triangle, its inner margin being close against the outer edge of the sterno-mastoid muscle. The finger, passed behind the muscle, received a very strong impulse, and the vessel, as far as it could thus be traced towards its second part, appeared to be enlarged. The pulse varied from 130 to 140, and was very full. No pulse could, as a rule, be felt in the right radial artery, but occasionally it could be made out as a faint flicker. The arm could not be raised from the side; the pain in the shoulder was unbearable, and the patient lay in bed with his left hand grasping that part tightly, as he said that doing so gave him some relief. The heart sounds were healthy; the pupils were regular; there was no cough and no laryngeal irritation. The other functions of the body were natural.

The patient was kept under observation for a week, being at the same time treated with tincture of digitalis, but without any impression being made upon the rapidity of the pulse. I then had a consultation with my colleagues, Mr. Stokes, Mr. Thornley Stoker, and Mr. Corley, and I also had the advantage of the assistance of Dr. Robert McDonnell and Dr. Bennet, Professor of Surgery in the University of Dublin. The majority of opinion was in favor of attempting an operation upon the first part of the subclavian, and, in the event of that proving diseased, upon the innominate. I put the case before the patient, who consented to the proposal; but after an interview with his son, he declined it. He remained, however, in hospital, and I then tried for some time the iodide of potassium treatment, but without any appreciable result. The pulse still continued high, and the tumor increased in size, while the pain in the arm was combated by frequent hypodermic injections of morphia. The patient suddenly took his discharge on the 30th of March, as he said he had "private business" to transact. He once visited me at my house some weeks afterwards. The tumor had then grown to a considerable size, passing upwards in the neck; the pain kept him from sleeping, for he now had no hypodermic injections. There was no pulsation to be felt in the radial or brachial arteries. He promised to come into hospital next day, but he did not return until the 22d of May. He now stated that during the preceding night the tumor had ceased to pulsate for over an hour. When I saw him, pulsation was as violent as ever; all the local symptoms were aggravated, but the pulse had fallen to 100. Measured by the callipers, the tumor now marked three and one-fourth inches in diameter in all directions. A further consultation was held, and ligature was again determined upon; but on the 29th, the day but one fixed for operation, I was sent for to see the patient. All pulsation had stopped in the aneurism, which was now hard and tense. I resolved therefore to postpone any operative interference. The pulsation returned after about ten hours, and next morning was as bad as before. He had now three minim doses of tincture of aconite every three hours, but the pulse was not affected. On the 31st, pulsation stopped for fifteen minutes, but then recurred, accompanied with great pain. He was now ordered three minim doses of tincture of aconite every hour for twelve hours, the effect to be watched. The pulse-rate, which had been 116, fell to 96; but next morning the pulse was full and bounding at 100. On the 4th of June, the patient said that the tumor had ceased to beat several times, but this was not verified by the resident pupil; the pulsation was, however, feeble. During all this time, in which I had the benefit of daily conference with my colleagues, the tumor continued to grow in size until it reached three and a half inches in diameter at the base. The movement of pulsation was observed over a large area. When the patient sat up, the shoulder and the whole scapular region rose and fell with each pulsation of the aneurism. The hope which we had entertained of spontaneous cure did not appear likely to be fulfilled, and, in face of the fact that the disease was progressing, we unanimously agreed that operation should no longer be delayed.

Accordingly, on June 9, when I was favored by the presence of many eminent surgeons, the patient was brought into the operating theatre, and placed in the usual position on his back, with the head thrown well towards the left side, and deeply anæsthetized. I

made a free incision along his clavicle, from the anterior margin of the sterno-mastoid outwards, and joined its inner extremity by an incision along the anterior border of the same muscle. The clavicular attachment of the muscle was divided and turned up, and then the sterno-mastoid and sterno-thyroid were cut, to uncover the carotid, carefully avoiding the branches of the omo-hyoidean plexus, which could be seen. The vessel was of very large size, so much so indeed that some of those present thought I had arrived at the innominate. This belief was encouraged by the fact that at first, pressure upon it with the finger stopped pulsation in the carotid higher up, and also in the tumor; but this did not always occur, and was evidently the result of pressure on the subclavian communicated from a distance. I now went further down in search of the bifurcation; but this was an extremely tedious and anxious proceeding, and I was compelled to divide nearly the whole of the sternal attachment of the sterno-mastoid. Coming at last upon the origins of the subclavian and the carotid, at what appeared to be an alarming depth, the difficulty of reaching the innominate beyond was increased by the sky becoming obscured by a heavy thunder-cloud, which seemed to shut out all the top light. A mirror was then used to throw light into the wound, but without much good result, and I was here much delayed. The sheath of the innominate was at last slowly scraped through, and using an ordinary aneurism needle for this purpose, I succeeded in passing it under the vessel, which appeared to be healthy. I then determined to thread it with ordinary silk, and to use this to draw back the tape ligature which Mr. Barwell had been good enough to send me. But failing in this, as the opening between the sheath and the vessel was too small, I withdrew all, and threading a special needle, invented by Mr. Barwell, with the curved portion movable by a lever, I introduced this with comparative ease. I then, before tying, tested the effect of pressure upon the vessel, between my finger and the tape; lifting the vessel freely from its bed, and finding that all movement ceased in the aneurism, and in the carotid, I secured the ligature with three knots, drawing the ends with moderate firmness. The edges of the wound were brought together, and a drainage tube having been introduced into the lower part, an antiseptic dressing was applied, and fixed by means of an elastic roller. The arm and shoulder were also swathed in sheets of wadding which had been previously heated. The patient was at once carried to bed, and I saw him again in half an hour. The right side of the face was cold, but the pupils were equal. He had not fully recovered from the effects of the ether, but I noticed that when he attempted to ask me some questions, he always broke down in the middle of the sentence, and then seemed to be trying to recollect what he wished to say. This was the only symptom of brain disturbance that ever presented itself, and in the evening he seemed to have his mental faculties perfectly unimpaired. He was ordered ice, milk and soda-water, and beef tea. Two hours after the operation, the patient complained of pain in the shoulder, and had one-third of a grain of morphia hypodermically, repeated in two hours. Slept for three hours during the evening. Evening temperature 100.6° Fahr. right side, 99.4° left; pulse 136. At 11 o'clock, 99.6° right side, 99° left; pulse 120. No pain.

10th (2d day). At 3 o'clock this morning the patient was seen by Mr. Kidd, house-surgeon. Complained of pain over region of the stomach, and was given a hypodermic injection of morphia. Slept for several hours. In the morning I saw the patient; his stomach was much distended with flatus; ordered turpentine stupes and a carminative. Temperature at 8.30, 99° on both sides; pulse 120. The abdominal symptoms were relieved. At 3.30 respirations were shallow and rapid—44. No pain. Finding that the temperature was then only 99°, and believing that the dyspnœa was caused by compression, I loosened the elastic bandage and the dressings, which gave much relief. Evening temperature 99.8° on both sides; pulse 132. Diet as before.

11th. About midnight, severe pain in right shoulder; pulse 148. Relieved by morphia. Passed a very good night. Morning temperature 99.4°; pulse 128; respiration normal. Wound dressed under spray. Slight serous discharge. Edges uniting. Drainage tube cleansed. Much pain in arm after dressing. Hypodermic injection of one-third of a grain of morphia. Slept nearly all day. Evening temperature 100.4°; pulse 128.

12th. Morning temperature 99°; pulse 120. Passed a good night. Looking remarkably well to day. No radial or temporal pulse. Carotid still. Tumor decidedly smaller, the wrinkles beginning to return in the hitherto tense skin. No pain until

evening, when there was a slight recurrence of it in the right arm. Evening temperature 98.8°; pulse 124.

13th. Morning temperature 99°; pulse 120. During early part of night complained of difficulty of breathing, and pain on swallowing, but afterwards passed a good night, sleeping soundly. Wound healed save at the drainage opening. Tube cleansed and returned. Slight serous discharge. Evening temperature 98.6°; pulse 124.

15th. Morning temperature 98.6°; pulse 108. Wound looking well and firmly closed up to the drainage tube, which was removed and replaced by a few strands of catgut. Patient a good deal troubled with tenesmus; enema did not give relief, and he was ordered a mild saline aperient, which was effective; bowels moved twice. Evening temperature 98.4°; pulse 116.

16th. Morning temperature 98.4°; pulse 132. Mixture of tincture of digitalis in 5 minim doses, and sulphate of quinia in 2 grain doses, every fourth hour. Evening temperature 98.4°; pulse 116.

17th. Morning temperature 98.4°; pulse 120. Wound dressed. Some healthy pus escaped from sinus. Can feel when the right hand is pinched. Very quiet day. Evening temperature 98.6°; pulse 104.

18th. Morning temperature 98.4°; pulse 100. Wound dressed with boracic lint. Patient only complains of being tired from keeping in one position. Expresses himself as being otherwise well. Evening temperature 98.4°; pulse 108.

19th. Morning temperature 98.4°; pulse 104. Wound syringed with carbolic lotion, 1 in 40. Only about a teaspoonful can be injected before it returns. The discharge seems to come from above the apex of flap. Evening temperature 98.8°; pulse 108.

20th. Morning temperature 98.8°; pulse 104. Pus small in quantity, quite healthy. Temperature, which has been normal for seven days, rose to 99.6° this evening. He had a good deal of stinging, burning pain in the hand this afternoon. Tumor measured in one diameter $2\frac{1}{2}$ and in the other $2\frac{7}{8}$ inches—showing an altered form, and giving a reduction of one inch in one direction, and of half an inch in the other. Evening temperature 99.6°; pulse 108.

21st. Morning temperature 98.6°; pulse 100. Passed a very quiet night. Sensation good in the arm, but still very imperfect in forearm. Still no radial or temporal pulse. Temperature of arm very good. Swallowing again very painful. Evening temperature 99.6°; pulse 100.

23d. Morning temperature 98.2°; pulse 100. Pain in right eyeball, and occipital headache. Ordered 20 grains of bromide of potassium, which had the effect of relieving him. Pulse fell to 96 in an hour and a half. Pain in right hand, as before, for a short time. In the evening pulse rose to 116, and temperature to 101°. As there was no apparent cause for this, I was sent for, and saw the patient with Mr. Corley. The wound was examined, but nothing could be found there to account for the increased fever. Ordered 20 grains of bromide of potassium, and ice. Deglutition not as difficult as yesterday.

24th. Morning temperature 98.4°; pulse 108. Passed a good night. Had a purgative. Pain in right hand and arm at intervals during the day. Wound healthy. Ordered $1\frac{1}{2}$ grains of quinia in pill, and a mixture containing 20 grains of bromide of potassium, and $1\frac{1}{2}$ fluidrachms of infusion of digitalis three times a day. Pulse and temperature at night again increased. Pain in hand very severe. Had hypodermic injection of morphia. Evening temperature 101°; pulse 128.

25th. Morning temperature 98.8°; pulse 108. Pain in head and eye returned. Temperature almost normal during the day, but again increased at night to 101°, after a severe attack of pain in the hand. Pulse 116 in the evening.

26th. Morning temperature 98.4°; pulse 116. Patient rather depressed this morning, for the first time since the operation. Sinus syringed out with carbolic acid, 1 in 40. A piece of ligature, about two lines long by a line broad, with some shreddy substance, was washed out. This, on subsequent examination under the microscope by Mr. P. S. Abraham, proved to be yellow elastic tissue. Presumably it was one of the cut ends beyond the knot, as it was sharply defined, and under the microscope, at one part, the fibres were suddenly turned upon themselves, as if forming part of the knot. Evening temperature 99.8°; pulse 120.

27th. Morning temperature 98.8°; pulse 100. Patient looks very well and passed

a very good night. Sinus surrounded with granulations. No pain in hand until towards evening, when it became severe. Temperature taken on both sides, when it was found to be 101.4° in the right axilla, and 100.4° in the left. Complained of heat in the right arm. Had a hypodermic injection, after which he slept for two hours, and awoke free from pain. Temperature again taken—right axilla, 99.6°, left 98.8°.

28th. Morning temperature 98.4°; pulse 104. Passed a good night. Swallowing easy. About half a drachm of pus escaped from sinus. Some shreds of yellow elastic tissue washed out. Pain in the arm again, followed by rise in temperature—right 100°, left 99.4°. Had a purgative mixture as before.

July 2 (24th day). Opening of sinus the size of a pin-hole. A few drops of pus escaped. Temp.: right 99.4°, left 99°.

July 4 (26th day). Sinus closed; pain in hand recurred as before.

July 6 (28th day). Sinus opened, and half a drachm of pus pressed out. Temperature rose to 100° in the evening.

July 8 (30th day). Pulsation visible at apex of flap, coming from portion of the innominate. Passed a very good day. At 11.15 P. M., patient noticed that he was bleeding. Hemorrhage had stopped when he was seen by the house-surgeon. Mr. Stokes and Mr. Thornley Stoker saw the patient with me soon afterwards. Wound examined; no bleeding. Dressing renewed with a shot-bag over all. Amount of blood lost about three ounces. Hypodermic injection of morphia. Ice.

July 9 (31st day). Passed a good day. No bleeding. Ergot ordered. Morning temp. 98.6°, pulse 100; evening temp. 100.4°, pulse 104.

July 10 (32d day). Very quiet day. $\frac{1}{120}$ gr. of atropia every fourth hour. Small quantity of pus.

July 11 (33d day). Some minute sloughs discharged on syringing.

July 14 (36th day). Says he is very well. Morning temp. 98.6°, evening 100°. Sulphide of calcium gr. $\frac{1}{4}$ three times a day.

July 16 (38th day). Patient says he has not felt so well since the operation. Morning temp. 98.2°, pulse 96; evening temp. 100°, pulse 104. A few drops of pus.

July 17 (39th day). At half-past three this morning a terrific hemorrhage took place. The clothes were saturated, and the blood ran in a large stream on the floor. The patient was greatly blanched and collapsed. Mr. Kidd gave a hypodermic injection of ether. Cold, clammy sweat, flickering pulse, voice a mere whisper. Patient did not lose consciousness, but said he could not see. When I saw the patient, bleeding had stopped. The patient had then rallied somewhat, and complained of pains in his head and limbs. Increased pressure was made with shot-bags, the dressings not being disturbed. Warm jars placed to feet and body. Further stimulation prohibited. Ice and beef-tea in small quantities.

July 18 (40th day). No bleeding. Seen with me by my colleagues, and by Dr. R. McDonnell and Professor Bennett. Very weak. Treatment as before. Pain in limbs treated with morphia.

July 19 (41st day). Has rallied considerably. His expression is much improved. Color has returned to his face, and his pulse is stronger, but jerky. Pain in limbs. As patient's bedding had not been disturbed since the hemorrhage, he was carefully lifted by seven persons, and a clean mattress, etc., substituted.

July 20 (42d day). Complained of difficulty of breathing at 2 A. M., and much pain. Had half a grain of morphia subcutaneously. Slept for some time, and died quietly at 8.15 A. M. There was no recurrence of bleeding.

*Post-mortem Examination.*—An autopsy was held a few hours after death, but as any interference had been forbidden by the patient's son, a partial examination only could be made. Only the parts actually involved in the disease and the operation could be removed.

A small opening in the skin was the only part that appeared unhealed. The rest of the incisions were firmly cicatrized. The size of the tumor was $2\frac{1}{12}$ by $2\frac{1}{2}$ inches. When the skin was reflected, there was no trace of infiltration of parts, and no sign of blood. The opening in the skin led into a small cavity containing about a drachm of pus. When this was removed, the cavity was found to be about three-quarters of an inch in depth, above and slightly behind the right sterno-clavicular articulation, point-

ing downwards, backwards, and inwards. It received the end of the little finger, like a thimble. The tumor itself was covered by skin and platysma, and some outer fibres of the sterno-mastoid muscle; the omo-hyoid was stretched across it. The phrenic nerve passed along the inner side, borne off by the anterior scalenus; the muscle was bulged forwards, but the nerve did not seem to be pressed upon. Across the whole surface of the tumor were, lightly stretched and flattened, large roots and branches of the brachial plexus. In the anterior inferior triangle the tissues overlying the great vessels were so matted together that they could only be dissected with difficulty, especially at the lower part of the carotid. The internal jugular was collapsed. The common carotid was full and firm to the touch as far as the bifurcation. The subclavian vein was empty, and was tightly stretched along the lower and anterior part of the tumor. Its coats were thin, and in two places, near the junction of the internal jugular, there were small translucent patches, apparently from thinning of the internal coat. A few drops of pus oozed out of the lower end of the carotid, into the ulcer which terminated the sinus. On turning forward the anterior scalenus, the aneurism was found to involve the second part of the artery. The tumor was found to rest upon the first rib, and to press against the clavicle in front. These bones were removed; the rib with its attachment to the aneurism, and as much of the aorta as could be reached, were cut across; and the parts were taken out *en masse.*

The tumor was found to spring from the posterior part of the second and third portions of the subclavian artery. It was flattened below, where it rested on the rib, and passed upwards for three inches, ending in a dome-like surface. Corresponding to the clavicle, it was constricted. Its clavicular portion measured two and one-eighth inches antero-posteriorly; its basal portion, two and three-quarters. The artery was elsewhere normal in size. It formed a cord from which the tumor sprang. The axillary portion, as far as it could be removed, was firmly plugged. All the vessels of the first portion were traced, and were pervious.

The ulceration, which was somewhat larger than a sixpence in area, was situated at the bifurcation of the innominate into the subclavian and carotid arteries. It involved the anterior portion of the walls, and, looking into it, the clots blocking the three vessels could be seen. The surface was gray and shreddy; there was no staining of blood visible; the vessels were partly slit, and a syringe was used to force water through them in the direction of the circulation, but although this was carefully tried with each vessel, not a drop passed through. The incisions were extended along the vessels towards the ulcer.

The wall of the innominate was thickened almost from its origin, and this thickening increased gradually as the site of the ligature was approached, until the depth was about two lines. The clot was firmly adherent to the walls, and extended backwards through the greater extent of the vessel. At its cardiac side was a tongue of organized clot, rather loosely attached, and between it and the firmly adherent clot were some retiform bands of fibrous tissue deeply stained with blood.

The subclavian was found to be empty, except at its cardiac end, which was well blocked with a firmly adherent clot. This projected towards the aneurism for about half an inch. No water could be forced through.

The common carotid felt solid, but on opening it, it was found that the centre of the clot had degenerated, and was occupied by pulpy, purulent material. The walls of the vessel were thickened; the clot terminated near the bifurcation into the external and internal carotids. The aorta was thickened, atheromatous, and in patches calcareous. The lung and pleura, as seen on the right side, were healthy.

An incision was made into the aneurism from summit to base; it contained about half an ounce of dark, thick blood, and in the centre was some passive clot occupying a cavity about the size of a walnut. The process of cure was evidenced by fibrinous layers upon the walls to the extent of a third of an inch, and on the inner sides of this coating were masses of coagulum, less firm, but evidently undergoing consolidation.

A prolonged and careful search was made for traces of the ligature, but none could be found. On the posterior surface of the innominate, opposite the ulceration, was some fatty tissue, intimately adherent to the wall, which could with difficulty be cleaned.

A more minute examination of the parts was subsequently made. The vessels were all divided into the ulcer. This showed that the innominate had been constricted at

about a quarter of an inch from the cardiac margin of the ulcer. The walls were not divided, and the ulcer had not taken origin at the site of the ligature. The vessel was not occluded by adhesion of the inner surfaces, but a chink remained at the ligatured portion, through which the clot was continued, and had been united to the clots in the subclavian and the carotid. The clot in the subclavian was well formed. The ulcer had eaten into the innominate at its centre, and had in this way doubtless caused the hemorrhage.

In order to search for the ligature, an inch of the posterior wall of the innominate was cut out, and several sections made by Mr. Abraham, but no trace of it could be found. The coats of the vessel were undivided.

The result of this case, although much to be regretted, clearly shows that the ligature had entirely succeeded, but that an abscess, resulting from imperfect healing of the wound, had opened into the innominate close to the bifurcation. No blood, however, had passed the point of deligation, nor had any descended the common carotid; the hemorrhage must, therefore, have been supplied by the vertebral.

The occurrence of an abscess, which, not having exit externally, burrowed deeply till the pus found its way into a vessel, is an accident hardly likely to recur. The fact that the vessels were closed on each side of the ligature by firm clot,[1] that the aneurism was far advanced in the process of cure, and, above all, that the coats of the vessel were, at the point of deligation, uninjured, vindicates, most completely, the principles which guided me in the choice of a flat ligature, viz., to leave the parietes of the vascular lumen intact and without breach of continuity. The fortuitous opening by an abscess into that lumen does not, in any way, affect or detract from that position. The case, though ending in death, proves even more conclusively than if it had been successful, the value of the ox-aorta ligature.

[1] That in the carotid had been subsequently softened by admixture with pus from without.

# INJURIES AND DISEASES OF NERVES.

BY

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THE different varieties of nerves (spinal nerves, cranial nerves, great sympathetic nerve) may be affected by the same lesions, which give rise to symptoms differing with each variety. In the case of the cranial nerves, the symptoms vary with each nerve, in consequence of its special function; therefore a general study of their lesions cannot be made. But this is not so with the spinal nerves, for whatever nerve is affected, the primary and secondary symptoms are always the same.

The general considerations which follow, relate, therefore, only to spinal nerves. The history of the lesions of the other varieties of nerves belongs to regional pathology.

We will successively consider: (1) Traumatic lesions of nerves, in connection with which will be given an account of the process of repair of nerves after wounds, and of the functional and trophic disturbances secondary to injuries of these organs; (2) Inflammatory lesions of nerves; (3) Neuralgia; (4) Tumors of nerves, and the affection known as painful subcutaneous tubercle; (5) Tetanus, in which disease the nervous element plays so important a part; and, finally, (6) The various operations which are practised upon nerves.

## TRAUMATIC LESIONS OF NERVES.

The primary and secondary symptoms of traumatic nerve lesions are pretty much the same as regards their nature, in the different injuries. But they differ in their intensity, their acuteness, their dissemination, their duration, and the greater or less simultaneousness of their development, according to the nature of the lesions. Therefore a general study of traumatisms of nerves is not sufficient. It is essential to examine each of them successively, pointing out the special symptoms in each case, and referring to a special section for the complete study of each of these symptoms. This method of proceeding will permit us, moreover, to give in connection with the several varieties of injury, the indications for immediate treatment applicable to each.

We may, with Tripier, divide traumatisms of nerves into two principal

groups, according to whether there is or is not a wound of the integument. But this division is not justifiable in every case, for lesions of the nerves which may occur without a lesion of the integument, may also exist when there is a wound of this structure.

We will consider: (1) Concussion, compression, contusion, and crushing; (2) Stretching and avulsion—these lesions may occur without a wound of the integument; (3) Punctures, cuts, contused and gunshot wounds, and wounds attended with lodgment of foreign bodies, in connection with which the ligation of nerves will be referred to; and (4) The phenomena consecutive to injuries of nerves, which are found to present certain differences in each variety of wound.

## I. Concussion, Compression, Contusion and Crushing of Nerves.

Concussion.—We will first consider briefly *concussion* of nerves, under which head were formerly placed all those functional lesions of the nerve trunks which were unaccompanied by any appreciable anatomical change. Formerly, cases of slight and indirect contusion were referred to this condition, and through its mechanism were explained the disturbances frequently observed in the functions of the nerves in the neighborhood of that which had been wounded. At the present day, however, the progress made in pathological anatomy and physiology has restricted the field of concussion. It may continue to be described as a clinical type, but the attempt is made to connect it with anatomical alterations, as yet, it is true, but little understood. The most probable lesion of concussion, according to Tillaux, is a disintegration, or momentary coagulation, of the medullary substance of the nerve.

Compression of Nerves.—*Rapid Compression: Pathological Anatomy and Physiology.*—Rapid, sudden, or acute compression is to be distinguished from that variety which occurs slowly. The former is usually manifested by very intense pains, and its mechanism presents close analogies to that of contusion. Slow compression, on the contrary, occasions nutritive alterations, particularly in the muscles, without sensory phenomena of any description.

Vulpian and Bastien have experimentally studied rapid compression; they describe two periods—one of *increase*, which is limited by the duration of the compression, the other of *decline*, which comprises the phenomena consecutive to the compression. Each of these periods includes four stages. In the first period there are: (1) A stage of tingling and formication with a sensation of heat and cramps: this stage lasts from two to ten minutes; (2) An intermediate stage, or that of remission, which lasts from a few seconds to a quarter of an hour; (3) A stage of hyperæsthesia of the skin only; and (4) A stage of progressive anæsthesia, sometimes with persistence or exaggeration of the pain, and vague and paroxysmal pains in the muscles, which at first experience a feeling of fatigue, and which subsequently are paralyzed. In the second period there are: (1) A stage of paralysis, without deep pain, continuing two or more minutes; (2) A stage of reappearance of the muscular function, and then of sensibility, except the sense of temperature; (3) An intermediate stage, with more perfect return of sensibility and movement; and (4) A final stage, marked by a sensation of cold and weight, general malaise, nervous erethism, muscular spasms, and formication, with a reappearance of sensibility to temperature.

The experiments of Waller and the labors of Weir Mitchell have essentially confirmed the preceding results, the differences relating only to the

inconstancy of the intermediate stage, the diffusion of the muscular paralysis in the zone of neighboring nerves, and, finally, to the fact that if the compression is neither intense nor prolonged, sensation rapidly returns, while in the contrary condition several days may elapse before it is re-established.

According to Weir Mitchell, who has endeavored to determine the force necessary to abolish nervous conductibility, compression acts solely in a mechanical manner. He has found, in the animals upon which he has experimented, some traces of congestion, and especially a change in the state of the contents of the nerve-tubes resembling that seen in nerves which have been divided for seven or eight days; and it is to these disturbances that he attributes the loss of sensation. But these lesions still continue to exist when sensation has reappeared, and it becomes necessary, therefore, to look for another cause, which is probably, as maintained by Tripier, a disturbance of the circulation. In conclusion, it is seen that the mechanism of the lesions of compression has not as yet been thoroughly elucidated.

*Etiology.*—Compression of nerves may be due to two sets of causes: traumatic causes and inflammatory lesions.

(1) *Traumatic compression* may arise from an unnatural position during sleep, as in the radial paralysis termed rheumatismal, which is always, according to Panas, due to a direct compression of the nerve by the head, or by a resisting body, such as the back of a chair; it may also be due to the pressure of a band, or fetter, or even to the pressure of the bridal-rein against the third finger, in the case of horsemen after prolonged marches; to the pressure from the handle of a basket or bucket (paralysis of the water-carriers of Rennes), or from the head of a crutch pressing upon the brachial plexus, or to the compression produced by the forceps or fœtal head upon the nerves of the pelvis. In the fœtus, traumatic compression, usually of the facial nerve, has been described by Dubois and Noisier, ordinarily caused by the forceps, but sometimes due to a malformation in the pelvis of the mother, or even to the sacro-vertebral angle. Finally, some authors admit also the accumulation of fecal matter as a cause of compression of the lumbar plexus of nerves, and the compression of nerves by contracted muscles. But the disturbances observed in the latter case seem to be more connected with venous stasis, and the pains which at times occur in the posterior region of the thigh after the evacuation of scybala, appear to be reflex pains, due to the exaggerated distension of the intestinal walls. In these cases, when a lumbar pain is present, it is more likely due to localized peritonitis than to nerve compression.

(2) *Compression from inflammatory lesions* is most frequently due to a neighboring inflammation; the compression is here produced by the vascular dilatation and infiltration of plastic products around the nerve, without any change in the interior of the nerve itself, beyond a passive hyperæmia.[1] The pain is much more acute in affections of the osseous tissues, which are not extensile, than in the soft tissues. But, moreover, according to Tripier, the nerve element is directly influenced by the disturbances of the circulation which occasion the hyperæsthesia. This writer believes that the interference with the circulation plays the principal part in the compression of nerve fibres by retractile cicatrices.

Then, too, a nerve may be compressed by callus, whether or not it is involved in the mass of the latter. In this case it is still a secondary inflammation which causes the pain. A healthy nerve may be inclosed by callus, without being either compressed or painful.

*Symptoms.*—For the symptoms which occur in cases of *slight compression*,

[1] The compression of nerves in inflammation explains the relief which follows when the inflamed tissues are incised.

it is sufficient to refer to the results of physiological experimentation already quoted, bearing in mind the differences which always exist in pathological cases.

The first symptom in *severe compression* is the pain, which generally occurs immediately, and extends throughout the entire territory to which the injured nerve is distributed; it may continue several hours or even days, accompanied or followed by formication, hyperæsthesia, numbness, and finally motor paralysis, which may also occur at the outset when the compression is sudden and violent, or when it is produced during sleep, as, for example, in the case of radial paralysis. There is also met with, but less frequently, a more or less complete loss of general or spinal sensibility. After a variable period, the pain, formication, and paralysis successively disappear, sensation returning simultaneously with or before the power of motion. If the compression has been sufficiently severe, this period of reparation may be preceded by a slow atrophy. A constant sensation of cold in the paralyzed part has also been observed, being met with especially in the severe cases. The electro-muscular contractility, according to Guénot, may be abolished, diminished, or intact.

In the compression of nerves caused by the head of the crutch, studied by Laféron and by myself, the numbness and paralysis progress from the distal extremity of the limb towards its proximal end; their course is usually slow, but the paralysis may occur suddenly after a violent effort, and it is almost always only in the territory of the radial nerve that these disturbances occur; in these cases there is at times paralysis of the sensitive fibres of the nerve, the condition differing in this respect from the so-called rheumatic radial paralysis. The nerve next most often compressed by the crutch-head is the ulnar. This variety of paralysis, however, is seldom grave; and Laféron reports only one case of secondary atrophy, and that occurring in a child which presented some doubtful signs of infantile paralysis.

*Slow compression of nerves* may be produced by the development of tumors, especially of malignant tumors which involve the cellular sheath, and undergo secondary contraction. The nerve-fibres may also be compressed by the development of a tumor in the thickness of the nerve (neuroma). But the most frequent causes of this variety of compression are seated in the spinal canal, and consequently act upon the roots of the nerves. These are tumefactions, either meningeal (sarcoma, psammoma, echinococcus, internal pachymeningitis), or extra-meningeal and developed in the cellulo-adipose tissue of the canal (carcinoma, sarcoma, hydatid cyst, abscess), or finally vertebral (Pott's disease, cancer of the vertebræ).

The peculiar *symptoms of slow compression*, according to Tripier, are nutritive changes, affecting especially the muscles, without sensory phenomena of any kind; but clinically they are almost always accompanied by the symptoms of neuritis, or, at least, of nerve irritation, determined by the prolonged compression. When the cause of the compression is seated in the spinal canal, the cord is more or less rapidly affected; but generally the symptoms of nerve compression show themselves first, and remain isolated for a certain period before the appearance of symptoms referable to the medulla.

Compression of the nerve-roots manifests itself by three kinds of phenomena: pain, paralysis, and trophic disturbances. The *pain* is peripheral, and affects the territory supplied by the compressed nerve, constituting pseudo-neuralgia. It is usually permanent, with exacerbations, caused especially by movements. This pain may be accompanied with hyperæsthesia of the skin, particularly at the beginning. At a more advanced period the painful anæsthesia of authors

(*anæsthesia dolorosa*) is met with. It consists of an insensibility of the skin, with persistence of the spontaneous pains. *Paralysis* is not a constant symptom of slow compression; it is particularly rare to find it accompanied by contractures. The *trophic disturbances* are analogous to those met with after wounds of nerves; those most frequently seen are herpes zoster, bullous eruptions, at times gangrenous patches, joint affections, and, finally, muscular atrophy, which may exist without paralysis. Trophic disturbances of the eye have been noticed in cases of compression of the trigeminal nerve by an intra-cranial tumor.

In this triad of symptoms—pain, paralysis, and trophic disturbances—the influence of the inflammatory process must not be forgotten. It is to it, probably, that are due the pain and the rapidity sometimes observed in the evolution of the paralysis and trophic disturbances. Indeed, slow compression may occur without sensory phenomena, while the trophic and functional disturbances which it produces may have an insidious course, and for a certain time remain unrecognized, not attracting attention until the occurrence of some accident or disease which is apt to be considered as their sole cause. Weir Mitchell cites, in this connection, the very interesting case of a little boy who limped in walking, and whose lameness was attributed to a recent fall, while in fact it was due to an old typhlitis which compressed the nerves in the pelvis, and had already caused a noticeable atrophy of the muscles of the lower extremity. Unfortunately, as this author remarks, a didactic exposition of the symptomatology of this lesion is almost impossible, on account of the variations it presents according to the degree of the compression.

*Diagnosis of Nerve Compression.*—*Rapid* or *acute compression* of nerves may be confounded with *lead palsy*, which is distinguished from it by the loss of muscular contractility, by the immunity of the supinator longus, by the ordinarily bilateral nature of the disease, and by the progressive muscular atrophy which accompanies it, and which is characterized by beginning in the adductor muscles of the thumb, by the slowness of its course, by the considerable wasting of the muscles, by the irregular distribution of the atrophy, by the preservation of the cutaneous sensibility, and finally by the cramps and fibrillar contractions which are seen in the muscles beginning to be affected.

*Slow compression* is especially liable to be confounded with the effect of a recent traumatism, and with a cerebral or spinal lesion. I shall not revert to the characteristics which distinguish it from *recent traumatisms*, as these have been sufficiently described under the heading of symptomatology. *Cerebral lesions* are recognized by their often sudden onset, by the greater frequency and isolated loss of movement, and finally by the persistent excitability of the muscles by electric currents. Lesions of the *spinal cord* are generally bilateral, and the muscles are still irritable, if the lesion is not too extended; in the latter case, the other symptoms would leave no doubt as to diagnosis. In cases of anæsthesia of the skin, the procedure of Stich may be resorted to; if the skin where anæsthesia is present can be made the starting point of reflex action, the lesion is central, but otherwise nothing can be affirmed upon this question. Finally, Weir Mitchell has remarked that in affections of the nerve trunks the sense of touch is lost at once when it is going to be so at all, while in lesions of the nerve centres of a progressive character, there is at first a gradually increasing retardation in the transmission of tactile impressions, before their complete disappearance.

*Prognosis of Nerve Compression.*—The prognosis as regards the local condition is dependent upon the state of the faradic muscular contractility: it is

more unfavorable if the muscles no longer contract; no case, however, should be considered hopeless. The prognosis of slow compression depends upon its duration, and especially upon its cause, the removal of which affords the only hope of recovery.

*Treatment of Nerve Compression.*—The treatment of this lesion offers nothing special; it consists in the methodical application of electricity to the muscles, in order to prevent their atrophy. The cause of the nervous compression should be immediately removed. Patients who use crutches should have them made with two branches [and a hand-rest, so as to relieve the axillary nerves], and of suitable length.

Contusion and Crushing of Nerves.—*Contusion: Pathological Anatomy and Physiology.*—The slight habitual gravity of these lesions has rendered their study difficult in man, and accordingly the chief information that we possess upon the subject, especially as regards pathological anatomy, has been obtained from physiological experiments, the most important of which have been those of Tillaux, Weir Mitchell, and Arloing and Tripier. Let me say at once that Tripier blames the first two observers for having departed somewhat from the conditions found in clinical practice, by dealing directly with the denuded nerve trunks. Their results, however, coincide with those of Arloing and Tripier. In cases of slight contusion, the last-mentioned authors have never found any lesions of the nerve fibres; after more severe contusions there have been observed a very slight hemorrhage and a tearing of a few nerve fibres; but generally there are seen only very trivial alterations, irregularities of contour, and a moniliform appearance. If the nerves are examined at the end of several days, when the paralysis has almost disappeared, in the animals experimented upon, there is found scarcely any appreciable trace of these lesions.

Finally, after the most violent contusions, there is seen a hemorrhage which separates the nerve from its sheath, traversing the lamellæ of the perineurium, and sometimes insinuating itself into the midst of the nerve fibres; secondarily, the nerve trunks thus injured present the same alterations as follow incomplete sections, with the exception of the interruption of continuity of the nerve fibres. At a later period, the axis cylinder probably also disappears. It is in these cases of violent contusion that a consecutive tumefaction of the nerve may be observed, sufficiently marked to simulate a neuroma (Tripier).

*Etiology.*—Slight contusion is the most frequent traumatism of nerves. Cases of violent contusion are seldom met with, on account of the deep position of the nerve trunks and their mobility, which permits them usually to elude the vulnerating agent.

Contusions of nerves may be caused by direct force, the nerve being caught between a resisting surface and the body causing the contusion; as in luxations of the shoulder, for instance, which frequently lead to paralysis of the circumflex nerve by contusion and stretching, or in fractures, in which the contusion may be due to the vulnerating agent, or to fragments of bone, splinters, etc.

*Symptoms.*—Contusion of a nerve generally occasions a transient *pain*, accompanied with *formication* and *numbness;* these symptoms are usually of short duration, and probably correspond to those cases of slight contusion after which, in animals, no lesions have been found. On the other hand, it sometimes happens that with the same functional disturbances at the beginning, there supervenes, more or less tardily, muscular atrophy, preceded

or not by pains. Some authors even report cases of late, grave disturbance, without any symptoms having occurred at the time of the injury. Almost constantly, however, when the contusion is violent, it is immediately manifested by a more complex set of symptoms, pain, immediate and very acute, lasting from a few minutes to several hours, accompanied or followed by a numbness of variable duration, and, finally, succeeded by more or less complete paralysis, both of sensation and motion, the onset of which may be delayed until several weeks after the occurrence of the injury. In the latter case, according to Tripier, it will generally be found to be due to inflammation, or to nutritive disturbances, which react in turn upon the nerve centres.

Such are the signs of contusions of *mixed nerves*, which, moreover, are those most frequently affected. If the traumatism affects *nerves of general sensation*, the clinical picture differs only in the absence of muscular paralysis, but it is then particularly that anæsthesia and analgesia may be seen to exist separately. In regard to the *nerves of special sense*, they may be directly injured, and there is then present an exaggeration or destruction of their functions; a lesion of the fifth pair would also compromise the functional activity of the nerves of special sense. Finally, death may result from the contusion of certain nerves.

*Course and Terminations.*—The paralysis generally diminishes and disappears spontaneously, or in consequence of treatment, unless as the result of a complete crushing of the nerve, concerning which a few words will be said hereafter, or of some complication. Sensations of pricking, and sometimes tolerably acute pains, announce the return of sensibility, which usually precedes that of motion, although the contrary is not rare. The electric contractility returns pretty quickly, and always before voluntary movements. The re-establishment of the functions takes place from the proximal towards the distal extremity of the affected members; the paralysis may continue for a few days, or may be permanent, but generally complete recovery is obtained.

The most annoying and the most frequent complication of nerve contusion is neuritis, with the trophic disturbances which are its consequence, and of which the determining cause frequently remains unknown. According to Duchenne de Boulogne, it is due to a deep-seated lesion of the nerves, and is especially to be dreaded when the muscles have lost their electric contractility; the atrophy will never be marked when electric contractility is preserved.

Muscular atrophy generally begins during the first month following the injury. It manifests itself by deformities of two kinds—some due to the disappearance of the contour of the muscles, the others to the action of antagonistic muscles. This atrophy is studied in the section devoted to nutritive disturbances secondary to nerve wounds.

*Crushing of Nerves.*—Tripier insists that this term should be reserved for cases in which all the nerve-fibres are affected, and their power of transmitting impressions destroyed. More or less acute pain is observed at the moment of injury—pain which may be absent if the disorganization is complete from the outset. The only symptom peculiar to crushing is the total abolition of the affected nerve's power of transmitting impressions, and, in consequence, the complete disappearance of the power of motion and sensation in the territory supplied by the injured nerve. This complete motor and sensory paralysis is not always easily recognized soon after the occurrence of the accident.

The cases which may simulate this lesion are those in which traumatic

shock is present, or merely local numbness.[1] Therefore it is not important to test the sensibility at the moment of the accident; and even complete anæsthesia does not indicate crushing, unless it persists for several days. The paralysis and total anæsthesia may, on the other hand, be overlooked, on account of recurrent sensibility and substituted mobility; but it is sufficient to understand these phenomena in order to ascribe to them their due importance.

Following these injuries, the phenomena of inflammatory reaction are frequently very marked, and the process of reparation is long and difficult, especially if the crushing involves some extent of the nerve trunk. In crushing, the continuity of the nerve is not destroyed, because the neurilemma remains untorn; but there is a more or less complete rupture of the nerve fibres, the spaces thus produced being filled with blood and myeline. Beyond the seat of the crushing, the nerves sometimes insensibly resume their calibre, sometimes they appear irregularly dilated. In examining the nerve after five or six days, there can be sometimes found degeneration of nerve fibres which do not present any traces of injury, and which have only been the seat of general agitation or distension.[2]

*Diagnosis of Contusion and Crushing of Nerves.*—If the patient is seen soon after the injury, the history and traces of the contusion of the soft parts give some clue to the nature of the lesion. At a later period, and in the absence of any precise information, the paralysis from contusion of a nerve may be confounded with that due to *cerebral causes*, distinguishable by the perfect preservation of the reflexes and of electro-muscular contractility; or with *lead palsy*, which may be particularly recognized by the persistence of the action of the supinator.

The determination of the injured nerve is deduced from a knowledge of its course and distribution. In regard to the latter question, it has been already said that the lesions may seem to be more extended than they are in reality, on account of the local numbness, which is more or less pronounced at the moment of the injury. It must also be remembered that there may exist a semi-paralysis of the muscles which are innervated by the nerves in the proximity of the injured nerve; a phenomenon which was formerly attributed to concussion of these nerves (Follin).

As to the diagnosis of the degree of the lesion, this can only be made some time after the injury, and depends, as we have seen, on the more or less complete disappearance of mobility and sensibility, and above all upon the state of the electric contractility of the muscles.

*Prognosis.*—The prognosis of nerve contusion is not always grave, even when this has been very severe; the inflammation which supervenes may rapidly subside; nevertheless, according to Weir Mitchell, the lesions which follow contusion are more enduring than those which depend upon a different nervous lesion apparently more severe. The danger is evidently proportionate to the degree of the nervous lesion, and accordingly the state of the electro-muscular contractility determines the prognosis. The hyperæsthesia which sometimes follows faradization is a favorable symptom. On the contrary, contraction of the atrophied muscles is a sign of ill omen.

[1] But in extensive wounds by crushing, such as are met with in railroad accidents, the traumatic shock may be attributed to the crushing of the peripheral nerves, which reacts upon the nerve centres.

[2] Crushing a nerve by means of forceps has been sometimes practised in addition to its elongation. (Verneuil.)

*Treatment.*—Slight contusions do not require any treatment. If it is thought that inflammatory complications are to be feared, perfect rest of the parts, and resolvents, may be ordered. If inflammation supervenes, emollients should be prescribed; afterwards, when the lesion of the nerve and of the surrounding tissues has been cured, steam baths, frictions, massage, etc., will be indicated in order to arouse the excitability of the parts. Local faradization serves to oppose the atrophy of the muscles, and restores their voluntary contractility.

## II. Stretching and Avulsion of Nerves.

The term *avulsion* or *tearing* of nerves is employed to designate solutions of continuity of these structures, occurring in their course, or at their origin, as the result of excessive extension. The term *elongation* is reserved for the extension of nerves employed for a therapeutic purpose. During the past few years this method of treatment has acquired great importance, and it will be considered in the chapter devoted to operations upon nerves.

It is useless to dwell very much upon the *accidental extension* of nerves, the history of which will be found included in that of *surgical distension* or *elongation.*

*Etiology.*—The stretching of nerves may be *slow* or *sudden;* in the former case it may be due to the development of a pathological tissue, in the latter to displacement of a bone by *luxation* or *fracture*, or to certain violent movements, as in forced flexion of the thigh—a position in which the sciatic nerve is extended and spread out over the neck of the femur, as I have been able to determine experimentally upon the cadaver. Campenon reported to the Clinical Society of Paris the case of a man who had a temporary paralysis of the leg, caused by remaining too long a time upon his knees, seated upon his heel, with his thigh extremely flexed. But the most frequent cause of nerve extension is found in tractions upon the limbs, notably those practised with therapeutic intent, in reducing fractures and luxations, and especially luxations of the shoulder. This accident is particularly apt to occur when the luxation is one of long standing, which Tripier explains by the fact of the formation of partial adhesions, which prevent the nerve trunks from sliding freely in the cellular tissue which surrounds them, thus confining the stretching to a limited portion of the nerve, instead of permitting it to distribute itself over the entire length. Avulsion of nerves may also be observed in these conditions, as proved by the well-known case of Flaubert, in which the tearing of the brachial plexus from its spinal origin resulted from attempts to reduce a luxation of the shoulder. It is scarcely necessary to say that avulsion of nerves is met with in cases of total tearing away of a limb. The lesion may also complicate certain contused wounds, such, for example, as those made with hook-shaped instruments.

*Pathological Anatomy.*—The lesions of nerve extension will be described in connection with the operation of elongation. In regard to laceration, it may be complete or incomplete; the different parts of a nerve are not in fact equally extensible; the nerve fibres are generally broken all at the same level, before the neurilemma, which resists longer and is stretched out like a glass tube heated in the flame of a lamp. In some cases, the rupture may only affect a certain number of nerve fibres, but in these cases the unbroken fibres are so stretched, that they are changed in a manner which is sometimes irremediable. The rupture of nerves may occur at the point where the force has

been applied, but more frequently it takes place elsewhere—at points too variable, according to Trombetta, for any rule to be framed on the subject; according to the experiments of Tillaux, however, the sciatic nerve almost constantly gives way at the point of its emergence from the pelvis. As regards the resisting power of each nerve, reference may be made to what will be said in connection with the operation of elongation.

*Symptoms.*—The symptoms which characterize extension of nerves are all reproduced by the phenomena which are observed to follow elongation. Avulsion manifests itself by a complete loss of sensation and motion, with, according to Duchenne de Boulogne, disappearance of electro-contractility. In the case of Flaubert, already cited, there was total paralysis of the upper extremity, and of the lower extremity of the same side. Incomplete lacerations may cause the phenomena of neuritis; the secondary symptoms, however, do not differ from those observed as the result of complete sections of the nerves, which will be considered hereafter.

Sudden death, according to Tripier, is to be reckoned among the possible consequences of extension and tearing of nerves. This author, in fact, explains the cases of sudden death occurring during the reduction of shoulder luxations, under chloroform, by the existence of extensive lesions of the nerve-roots and of the spinal cord, resulting from pulling on the nerve trunks.

*Diagnosis.*—The functional disturbances which are observed to follow injuries to nerves point distinctly to the presence of a nerve lesion. But it is often difficult to recognize at once whether the injury is a contusion, an extension, or a rupture of the nerve. Apart from the etiological considerations which may render the diagnosis very easy, rupture may be excluded if motion or sensation persist more or less completely; without a history of the case, nerve-extension cannot possibly be distinguished from contusion, except in cases of isolated paralysis of motion or sensation, in which cases it would be manifest that the lesion was not a contusion; finally, under the same circumstances, these lesions are liable to be confounded with paralysis due to a central cause. (See remarks on compression and contusion of nerves.)

*Prognosis.*—These nerve lesions do not appear of themselves, or in their consequences, to be more grave than other traumatisms of nerves. Regeneration seems, indeed, possible after avulsion; at least we are justified in thinking so on account of the cures obtained by Duchenne de Boulogne. (Follin.) A guarded prognosis should be given in cases of incomplete laceration, for fear that a neuritis might follow. Finally, the possibility of a sudden death should be remembered by the surgeon in his attempts at the reduction of old luxations of the shoulder.

*Treatment.*—The treatment does not differ from that of all nerve wounds; it consists in fixation of the part in a favorable position, the use of resolvents, of anodynes, and finally of electricity, to guard against muscular atrophy. The secondary lesions do not present any special indications for treatment, and the reader is therefore referred to what will be said upon the subject in connection with wounds of nerves.

## III. Wounds of Nerves.

*Classification.*—Wounds of nerves may be *simple*, or they may be *complicated*, either by a certain amount of contusion and crushing of the nerve-termina-

tions, or by lesions of the surrounding organs (vessels, muscles, etc.)—lesions which are almost always met with in connection with wounds of nerves which have not been produced experimentally—or, finally, by the presence of foreign bodies. According to their etiology, wounds of nerves are divided into punctured, incised, contused, and gunshot wounds; varieties which present numerous analogies with each other, and which differ, especially in their effects, according as the division of the nerve has been complete or incomplete; therefore we will not consider them separately, but will set forth first the phenomena which belong to wounds of nerves in general, and point out afterwards those which are peculiar to each variety.

*Etiology.*—We have seen that the different causes of nerve-wounds furnish a natural basis for their classification; the simple enumeration of these causes will indicate their mechanism, and it will be sufficient to mention cutting instruments, the lancet (in bleeding), pieces of window-glass, fragments of bottles, etc., among the most frequent causes of incised wounds; and railroad accidents, which often produce contused wounds. As regards foreign bodies, these may be fragments of the vulnerating agent—the point of a foil, a whip-lash, a shot, etc.; or they may come from the organism itself, as, for example, a splinter of bone. Ligatures around a nerve, when they do not cause its division, or when they remain in connection with the central part, may act as foreign bodies; it is, therefore, necessary to avoid, at all hazards, the inclusion of a nerve in the ligature of an artery.

*Pathological Physiology and Anatomy.*—Traumatisms of nerves almost exclusively affect those of animal life, especially the spinal nerves, and particularly the nerves of the extremities—more often those of the upper than those of the lower extremities, the nerves of the forearm, and among these the median and ulnar, being those which seem to be most frequently involved. The lesions of the integument and neighboring parts vary with the cause. It is evident that the derangement of the parts will be less in punctured than in contused wounds, in which there is, as a rule, more or less destruction of the soft tissues, even excluding those cases of general crushing of a limb, in which the injury to the nerve forms only an insignificant part of the lesion. Finally, there are usually observed as complications of nerve-sections, lesions of the muscles, tendons, and vessels—notably at the wrist, where the division of the tendons of the flexor carpi radialis and flexor carpi ulnaris often complicates wounds of the median and ulnar nerves.

The nerve-trunks themselves present alterations of different kinds. There may be a simple separation of the nerve-fibres, in what may be considered a typical puncture—though in reality some of the fibres are always divided; or a more or less complete section of the nerve-trunk, and varying separation of its two ends, this being greater when the nerve is less adherent to the surrounding tissues, and being always more marked, unless under special circumstances, in the upper than in the lower segment. Finally, the surfaces of the section may be smooth, as in experimental neurotomies, but are more often irregular and disorganized. Immediately after the injury there is seen at the level of the nerve-wound, if the section is incomplete, an effusion of blood, which is located either between the nerve-fasciculi, or between them and the neurilemma; if the division is complete and the separation marked, there occurs an effusion of blood, varying in amount, between the extremities of the nerve—an effusion which reunites and surrounds them. If the wound is a simple one, and the patient in good condition, the two extremities of the nerve are soon united by a cicatricial tissue, through which, if the separation is not too great, its continuity is ultimately re-established. It may be said at once that

the immediate union of a nerve has never been observed; we shall see hereafter, in studying the process of repair, what led surgeons to admit such an occurrence, in spite of the constant opposition of physiologists, who had never observed it in their vivisections.

When the ends of the nerve are too far separated, or when there exists an obstacle between them which prevents their union, they swell and are separately cicatrized, the central end being the most swollen—probably, according to Follin, on account of its greater vascularity. The distance at which the two ends of a nerve can no longer unite, varies with the age of the patient. From vivisections it is found that a gap of six or seven centimetres ($2\frac{3}{4}$ inches) is only exceptionally closed. The nerve-trunk of new formation is complete in animals at the end of from four to six months; in man the time has not yet been positively determined; the nerve-trunk always remains smaller than the original nerve. We shall see hereafter what are the phenomena of degeneration and regeneration which take place in the divided nerves, but the succession of phenomena is not always favorable, and different alterations may persist either in the peripheral end alone—as, for example, in case of absence of union and regeneration—or in the central end itself, as in the case of incomplete division. The lesions which are then met with are neuritis and sclerosis, which it is sufficient to mention here. These changes may extend far from the point originally injured, and frequently reach the nerve-centres. Finally, in some experimental cases, there has been found atrophy of certain portions of the spinal cord without appreciable lesion of the central end of the injured nerve (Avezon). The encysting and toleration of foreign bodies [within nerves], admitted by Tillaux on the authority of Otto Weber, must also be referred to. There are no cases to establish the fact of such a termination, which is possible, but must be brought about very slowly.

Beside the lesion of the nerve-tissue, there may also be found in chronic cases certain atrophic or dystrophic lesions in the territory supplied by the injured nerves, and even in that supplied by neighboring nerves. For the present I shall content myself with a mere mention of these lesions, which will be again referred to in connection with the secondary symptoms of nerve-wounds.

*Symptoms.*—The symptoms of nerve-wounds may be divided into the *primary symptoms*, which manifest themselves at the moment of the injury and during the following days, and the *secondary symptoms*, which supervene at a later period, and which depend upon the degeneration or inflammation of the injured nerve.

The primary symptoms are *local* or *general*. The latter, more seldom met with, are *general convulsions* which especially follow incomplete sections of nerves, and are due to the intensity of the pain and the nervous irritability of the patients, and, above all, to traumatic shock, which is said to be observed frequently in cases of contused wound of the neck (Weir Mitchell).

The primary local symptoms are *pain* and defects in *sensation* and *motion*. At times there is noticed a local stupor, which consists in inactivity, insensibility, and coldness of the limb, and which is especially seen in cases of gunshot wound. This symptom rarely occurs, except in connection with traumatic shock, in the other varieties of nerve-wounds, unless there has been considerable hemorrhage.

The pain is acute and persistent in cases of punctured and incomplete incised wounds, and is also acute, but of short duration, in cases of complete division. At other times it is lancinating and stinging; and sometimes it is absent, especially in cases of gunshot wound. If a foreign body is present, the pain persists, and is increased by the slightest touch.

The pain does not always occur at the moment of injury, but some seconds or some minutes afterwards; it may be located at some distance from the wounded nerve, and even upon the opposite side of the body (Weir Mitchell).

The immediate disturbances of sensibility and motility are generally absent in punctured and incomplete incised wounds of nerves, at least in animals, according to Arloing and Tripier, but, on the contrary, are constantly present in cases of complete division; they will be considered hereafter. Other authors have noticed after incomplete section an imperfect disappearance of motion and sensation, notably suppression of the former with preservation of the latter, or the separate loss of the muscular sense or of tactile sensibility. In complete nerve-sections, the rule is, the disappearance or diminution of sensibility and motility. Arloing and Tripier have remarked that exploration practised a short time after the injury, generally reveals paralysis and complete anæsthesia in the zone of the injured nerve, and frequently in that of the neighboring nerves; this phenomenon is due to the concussion of the nerve, and may last several days, if the traumatism has been violent. The general condition of the patient must also be considered; thus intoxication, free bleeding, or the fact of having recently submitted to surgical anæsthesia, explains in many cases the different results which have been obtained by several observers. The exact appreciation, however, of functional disturbances is far from being a simple affair, and it is therefore only when the patient has sufficiently recovered from his emotion and injury, that it is advisable to test his sensibility and power of movement.

Beside the paralysis and lessening of sensibility, there have been sometimes noted jerkings, tremblings, and tonic and clonic spasms. According to Weir Mitchell, there is observed at first an elevation of temperature, due to the paralysis of the vaso-motor nerves, and afterwards a fall, caused by a diminution in the calibre of the vessels.

I will not stop to describe the symptoms resulting from lesions of the *sensory nerves*, which are altogether of a special character, and which consist in the exaggeration or abolition of the functions of these nerves.

Between the primary and secondary symptoms may be placed the local accidents which may occur as complications of nerve-wounds. The most important of these are phlegmonous inflammation and neuritis, the latter seldom beginning before the second or third week, and often at a much later period. The acute form is extremely rare, the subacute or chronic form being that which is almost always met with. For more minute details as to the phenomena consecutive to wounds of nerves, the reader is referred to the section devoted specially to this subject.

It will be seen that the functional and trophic disturbances, consecutive to wounds of nerves, are divided into those which are peripheral and those which are due to central irritation.

I. The *peripheral disturbances* include: (1) *Sensory disturbances* (pain, causalgia, anæsthesia); (2) *Motor disturbances* (paralysis, spasms, electro-contractility); (3) *Nutritive disturbances*, among which are cutaneous lesions (glossy redness, phlyctenæ, pemphigoid eruptions, ulceration, herpes zoster, traumatic herpes); lesions of the epidermis, the hair, and the nails (see Plate XVII.); interference with the secretion of sweat and changes of the local temperature; lesions of the cellular tissue (œdema); lesions of the joints, bones, muscles, and tendons; and (4) *Neuro-paralytic inflammation.*

II. The *disturbances from central irritation* are divided into two classes, according as there is no apparent lesion of the nerve-centres (traumatic neuralgia, neuralgia of stump, convulsive spasms, general epilepsy, tetanus, mental disorders), or as the disturbances may be attributed to a myelitis,

which is itself consecutive to an ascending neuritis; in this class are placed the *reflex paralyses*, which are known as immediate paralyses without atrophy, and as late paralyses with muscular atrophy and myelitis.

*Diagnosis.*—The surgeon may be called upon to make the diagnosis in a case of nerve wound, either at the moment of injury, or a certain time afterwards, when the secondary symptoms have supervened. At the time of injury it is not difficult to make a diagnosis, the history, the site of the wound, the acute pain felt by the patient, and the various disturbances of motility and sensibility being sufficiently characteristic. But the diagnosis of the kind of wound is often very difficult, and is based chiefly upon the history and upon the lesions of the soft parts, which differ, for example, in incised wounds from those met with in contused wounds; nevertheless, an acute pain which radiated towards the periphery, without either disturbance of sensation or motion, would indicate a *punctured* wound; loss of sensation and motion in the region supplied by a nerve, without very acute pain, would suggest the presence of an *incised* wound; numbness and tingling would favor the idea of a *contused* wound; increase of pain and of the general symptoms, upon pressure, would be especially met with in cases complicated by the presence of *foreign bodies*, which under such circumstances would be commonly found by exploration of the wound, and, finally, the more or less complete loss of the functions of the injured nerve would distinguish a *complete* from an *incomplete* section.

The *diagnosis of the particular nerve which is injured* will depend upon a knowledge of the course and functions of each nerve. But great allowance must be made, in the appreciation of the symptoms, for the variations that may arise from the degree of excitability of the patient, and especially must the surgeon distrust the results furnished by examinations made immediately after the injury, as has been already pointed out when speaking of symptomatology. In conclusion, it is especially by observing the sequence of phenomena, the quick or slow appearance of the secondary symptoms, or, on the contrary, the rapid restoration of the nervous functions, that the diagnosis of the variety of the lesion may be arrived at, taking care in considering this last order of facts to avoid attributing to the injured nerve the sensibility which it owes to the recurrent filaments, and the movements produced through the muscles innervated by neighboring trunks.

When secondary symptoms are present, it is still to be remembered that they are due to an old nerve wound, and it must be decided whether we have to deal with a *neuritis* or a *sclerosis;* finally, it will be well to know whether the lesion has reacted upon the nerve centres, in order to appreciate the nature of the intervention required and the opportunity of its application.

The secondary symptoms of nerve-wounds may be confounded with cerebral, spinal, rheumatic, or lead palsies, which may be distinguished, the first by the retention of electro-muscular contractility, and the others by the general condition of the patient and the accompanying symptoms, but, above all, by the etiology, which is in truth the only certain means of diagnosis of surgical nerve-lesions. It is also important to be on the watch for old and forgotten morbid conditions, as, for example, a coxalgia dating from infancy, which may have caused disturbances of sensibility and motility that are only noticed by the patient upon receiving an injury, and that the surgeon may be tempted to attribute to a nerve lesion.

Finally, it must be remembered, that certain affections of the digital extremities (whitlows, burns, and chilblains) may be followed by trophic and functional disturbances which may also extend in these cases to the parts supplied by neighboring nerves.

As regards the *diagnosis of the cause of the secondary symptoms*, neuritis cannot be distinguished from sclerosis and atrophy of the nerve trunks, unless the secondary symptoms have supervened very quickly, or unless the neuritis has determined, previous to the paralysis, symptoms of motor excitation. Finally, the absence of exact limitation of the muscular paralysis, at a period remote from the infliction of the injury, should lead the surgeon to suspect a lesion of the nerve centres.

*Prognosis.*—Benign as far as the wound is concerned, traumatic lesions of nerves are grave through their consequences. The prognosis is the more serious in cases of incomplete division, and in those of contused wounds and wounds complicated by the presence of foreign bodies, which are more liable to be followed by the sequelæ referred to than those in which the nerve-section is complete. Moreover, in regard to recent wounds, the prognosis varies with the general condition of the patient, with the lesions of the surrounding parts, and, in general, with all the circumstances which may favor or retard the re-establishment of the nerve functions. A guarded prognosis should always be given, therefore, in cases of neuritis or persistent neuralgia, on account of the imminence of trophic disturbances.

In chronic cases, the prognosis depends upon the state of the electro-contractility of the muscles; but the absence of this should not lead the surgeon to despair of re-establishing their function, for it may be restored under the use of electrization. In cases of intense neuritis, there may be observed tonic contractions, which indicate the irreparable loss of the properties of the muscle, which, moreover, then undergoes atrophy with great rapidity.

*Treatment.*—The immediate treatment of wounds of nerves presents several indications; pain is to be obviated, as is inflammation, and separation of the ends of the nerve in cases of complete division. All authorities agree in advising rest of the limb, obtained, if necessary, by means of an immovable apparatus, in such a position that the injured nerve shall not be pulled upon; resolvents and antiphlogistics if the inflammatory complications are threatening; opiates, subcutaneous injections of muriate of morphia, or even inhalations of ether or chloroform, to allay the pain which immediately follows the injury, or preferably chloral if there is a tendency to muscular spasm; finally, at a later period, sulphate of quinia, if the neuralgia assumes an intermittent form. If the painful symptoms persist in spite of this medical treatment, which does not often occur, except in cases of punctured wound and of incomplete division of the nerve, surgical intervention becomes necessary, and instead of the cauterizations employed by the older surgeons, enlargement of the wound by incision is now preferred, that is to say, the conversion of an incomplete into a complete nerve-section. But the failure of medical treatment to relieve the early pain is not frequent enough to justify preventive incisions in all cases of incomplete division, as has been advised by some German authors. In order to obtain immobilization in a favorable position, Tripier recommends, in all cases of nerve wound, that the limb should be placed in a moderately tight silicate of potassium bandage, in which a fenestra can be cut, if the patient complain of pain, and which, if there is the slightest sign of constriction, can be transformed into a gutter [posterior splint] by splitting it in its entire length. But this method of treatment, though well adapted to many cases, may at times be dangerous on account of the obstacle which it offers to the examination of the parts, the local or general numbness perhaps preventing the patient from being conscious of a constriction which is the more dangerous that it is exerted upon

a limb of which the vascular and nervous equilibrium has been suddenly modified.

In cases of complete division of the nerve, besides the position to be given to the limb, the uniting of the ends of the nerve by means of a suture must be considered. This operation is to be described in a special section, and it will be sufficient to say here, that most surgeons of the present day admit that it is of itself a harmless operation, and one which should always be resorted to when it is possible. In cases of great contusion of the extremities of the nerves, some surgeons still advise the suture after resection of the disorganized portions of the nerve-trunks; Tripier, however, rejects this procedure as absolutely useless and dangerous.

Finally, in cases where a foreign body is imbedded in the substance of the nerve, or is in contact with its divided ends, the first indication is evidently to remove it as quickly as possible.

In regard to after treatment, it is advised, in cases of prolonged *anæsthesia*, to employ electrization of the skin without moisture, by means of a strong current applied with a metallic brush, or frictions with warm oil of turpentine, which are at times very painful. In case of *neuralgic pain*, after having ascertained that it is not caused by the presence of a foreign body, antiphlogistics, resolvents, and if there is neuritis, sedatives are indicated, and particularly water-dressing and blisters for causalgia; the treatment by opiates is appropriate if there is *sclerosis*, and, as a last resort, neurotomy, which, however, should only be employed after medical treatment has failed. Tripier prefers to operate by open incision, and simply divides the nerve; relapses in his opinion depending less upon early cicatrization of the nerve, than upon the persistence of other ways of transmission. But most surgeons advise resection of one or two centimetres [half an inch or an inch] of the nerve. Malgaigne, moreover, advised, in order to avoid any possibility of reunion, that both ends of the nerve should be folded back in loops, and that the lower end should be cauterized, or that a flap of tissue should be interposed between the cut extremities; even these precautions, however, do not always insure against relapses.

The treatment of the *motor disturbances* consists especially in electrization by induced currents, in order to prevent muscular atrophy and loss of contractility; electrical needles also may be employed. Methodical electrization may, as we have seen, even re-establish muscular contractility some time after it has disappeared. According to some authors, it is proper to wait until the nerve is repaired before applying interrupted or continued, and especially descending, currents.

In cases of muscular contraction, resort is had to prothetic apparatus, to forced straightening, to tenotomy, and particularly to baths, douches, and kneadings (massage).

When both ends of the nerve are separatedly cicatrized, it is a question whether they should be sought for and united by suture, or whether the peripheral end of the divided nerve might not be united to a neighboring nerve which has not been injured. It is to experimental physiology and clinical observation that we must look for a solution of this question, which at present cannot be answered.

Foreign Bodies in Nerve-Wounds.—To what has already been said concerning the presence of foreign bodies in wounds of nerves, it may be added that every foreign body gives rise to local irritation, and sometimes to unbearable pain and to severe accidents. The oft-quoted case of Dupuytren's may be cited, in which the patient died from tetanus, the end of a whip-lash being found at the autopsy imbedded in the ulnar nerve. Descot has pub-

lished a case of tetanus which supervened after an amputation of the thigh, and was attributed to the presence of a ligature knot in the sciatic nerve.

It has not been proved, as previously mentioned, that foreign bodies in nerves can become encysted or be tolerated.

In all these cases the consecutive symptoms are dependent upon the existence of neuritis, and at times the changes are so far advanced, that a return to the normal condition does not take place, even after the removal of the foreign body.

This, indeed, is the first indication to be fulfilled. In a case in which the pain persisted in spite of the removal of a grain of lead imbedded in the median, M. Le Fort obtained a cure by the operation of elongation or nerve-stretching.

LIGATION OF NERVES.—The study of foreign bodies in nerve-wounds leads to the consideration of the ligation of these organs. The importance of this accident, which may occur in various operations, renders it proper to devote a short space to its consideration. Its study may be pursued both from the side of experimental research and from that of clinical observation.

*Experimental Facts.*—Researches upon this point have been made for a long time by several authors, among whom may be mentioned Thierry, Valsalva, Descot, and Arloing and Tripier. The latter have determined that small nerve branches are almost severed by the thread; in the case of larger branches, the constriction never immediately interrupts the continuity of the nerve, on account of the resistance of the neurilemma, but the transmission of impressions does not take place. If a nerve has been tied at the same time as an artery possessing thick walls, by immediately removing the ligature, the integrity of a certain number of nerve fibres may be counted upon; this is important in regard to the motion of the parts. If the ligature is rapidly removed, the nerve subsequently presents a swollen appearance on a level with the point of compression.

The anatomical changes which follow ligation have been well described by Descot. There occurs a plastic infiltration above, below, and around the ligature; the two ends of the nerve are maintained in exact apposition by the thickening of the surrounding cellular tissue; they are never separated from each other.

Arloing and Tripier in their experiments have determined that animals feel pain at the moment of constriction, and that the functions of the nerve are interrupted; they have never observed any secondary nerve symptoms.

*Clinical Facts.*—Surgeons at the beginning of this century, while endeavoring to avoid including an artery and a nerve in the same ligature, did not believe that any danger could result from such an accident. Larrey and Swan opposed this opinion, and the former, in a case of tetanus, suspecting that one of the branches of the crural nerve was included in the ligature, cut the latter with the effect of producing a remission in the symptoms. We have already cited a case of Descot's, in which, the patient dying of tetanus, a ligature-knot was found in the sciatic nerve. In a case of Richerand's, the ulnar artery and nerve were included in the same ligature:—

"A sharp pain was felt in the ring and little fingers at the moment at which I tightened the knot," says Richerand; "the palmar surface of the little finger and the ulnar side of the ring finger lost their sensibility; this was gradually re-established, and they had recovered it at the end of fifteen days."

To recapitulate: Ligation of nerves, according to experiments upon animals, has not caused secondary nervous accidents; but can it be said from this that it must be the same in man? Unquestionably not. In some cases

eminent surgeons have believed that they had found the cause of tetanus in the presence of a ligature around a nerve. These cases must be seriously considered, and care should be taken, in ligating arteries, that the nerves are not included. If the occurrence of such an accident is recognized, the ligature should be cut without hesitation, contrary to the practice which would seem to be indicated by a remark of Richerand, quoted by Descot, to the effect that, if in a ligation the nerve is taken up at the same time as the artery, it is not necessary to recommence the manœuvre. The practice of arterial ligation *en masse* may also, therefore, be not without danger. On the removal of parts with the *écraseur* or ligature, there are generally encountered only small nerve ramifications, which are not protected with a thick neurilemma. These operations are painful, but do not appear to be accompanied secondarily by grave nervous symptoms.

Cauterization of Nerves.—But little need be said of the effects of cauterization upon nerves. Formerly employed in the treatment of certain diseases of the nerves, it is at the present day abandoned. It is to be remembered that the nerve-trunks and branches, by the thickness of their sheaths and the mode of distribution of their vessels, resist, better than the other soft tissues, the different processes and agents of disorganization—burns and cauterizations. This is a fact which should not be forgotten in cases of deep burn. Ranke admits that heat may cause rigidity of nerves, as it does muscular rigidity. Some authors also admit that the physical and chemical constitution of nerves may be modified by cold. Crecchio has seen the medullary substance of the nerve-fibres become solid, a phenomenon accompanied by suppression of every nervous manifestation.

Cauterization is seldom followed by accidents. There is, however, a case recorded by Dr. Frère, in which an application of caustic potassa involved the musculo-cutaneous nerve; there ensued a flexion of the forearm upon the arm, trismus, and tetanic contraction of the muscles of the neck and trunk, and the patient died on the fifth day.

## IV. Phenomena Consecutive to Injuries of Nerves.

Process of Repair after Wounds of Nerves.—The knowledge of the phenomena which result in the regeneration of nerves after traumatisms which have destroyed their continuity, is entirely due to experimental physiology. It is by the aid of experiments made upon animals that it has been possible to follow, day by day, the delicate modifications which are produced in the intimate structure of the divided nerve-trunks, and which in time bring about, with an anatomical restoration *ad integrum*, the re-establishment of the suppressed functions.

The discovery of Waller, in showing that every nerve separated from its trophic centre undergoes a complete degeneration of its peripheral end, marks the first step in this line of research. Waller saw, at the same time, that the degenerated segment was not for ever destroyed, but that after a certain time there took place a true work of regeneration. He considered this regeneration to be the result of a kind of budding of the nerve-fibre remaining in connection with the axis cylinder, the parts of the nerve separated from the centre not taking any part in the process. The experiments of Remak, Schiff, Vulpian, Neumann, and Ranvier, have completed the teachings of Waller.

In order to thoroughly understand the manner in which the repair of a divided nerve is effected, it is well to rapidly review the *modifications under-*

*gone by the peripheral end*, as they have been made known to us by the researches of the above-named physiologists.

During the first twenty-four hours which follow the section of a nerve—the sciatic of a rabbit, for example—the nucleus of each nerve-segment is seen to increase considerably in size; the protoplasm swells and enlarges; in places it is seen to encroach upon the myelin, and to produce in it an outline of segmentation. The segmentation of the myelin is completed on the following day, and the sheath of Schwann becomes filled with large masses, which are colored black by osmic acid. These masses continue to divide during the third day, and at the same time the axis-cylinder, until now intact, is cut in two at the position of the nucleus, while above and below it takes a moniliform appearance. From the fourth to the sixth day destruction is completed, the sheath of Schwann is filled with fine, fatty granules, and the axis-cylinder disappears, no trace of it remaining. The nucleus of the nerve-segment undergoes division, and heaps of nuclei are seen to be formed.

At this period the fat granules, which fill the sheath of nerve-fibre, seem to diffuse themselves outside of it. The cells of the endoneurium are filled with them, and also the endothelia of the neighboring bloodvessels. Ranvier thinks that this fatty overloading of the cellular elements is connected with the absorption and disappearance of the myelin of the nerve-fibre. From the seventh to the twentieth day, in fact, the axis-cylinder and myelin having disappeared, and the nuclei of new formation diminishing more and more, the sheath of Schwann becomes empty and folds upon itself, its walls joining together. About the thirtieth day after the section, there are only found empty sheaths of Schwann, strewed with flat nuclei surrounded by a desiccated protoplasm (Ranvier).

Such are the modifications undergone by the peripheral end. Analogous phenomena are produced in the central end, but they do not extend very high; the disintegration of the myelin, according to Ranvier, does not generally pass beyond the first annular constriction above the section. Moreover—a distinction of importance—the axis-cylinder does not undergo any alteration; it remains intact, distinctly fibrillar, a little enlarged up to the level of the section. It is in this central end that the process of repair begins. How is it produced?

We have said that in the peripheral segment the axis-cylinder disappears as well as the myelin. It cannot, then, be longer admitted, as formerly believed by Vulpian and Philippeaux, that the regeneration is due to the simple reproduction of the myelin sheath—an opinion which has, indeed, been abandoned by both these authors themselves. Others thought that the axis-cylinder was simply re-formed in each of the old empty sheaths of Schwann, and was surrounded with an envelope of myelin. The idea advanced by Waller of the budding of the nerve-fibres of the central end is the opinion which Ranvier has been led by his researches to recognize as true. The following is, according to the learned Professor of the College of France, the *process of repair*:—

Each end of the cut nerve swells so as to form a kind of bud—the *central bud* and the *peripheral bud;* these two swellings are united by a tissue analogous to that of granulations—the *cicatricial segment.*

In the central segment, as early as the eighteenth day after the traumatism, the budding of the nerve-fibres begins to take place. It is at the level of the first annular constriction seated above the section that the fibres of new formation appear. Ranvier has carefully described the different forms taken by the new nerve-fibres. Sometimes there is seen a myelinic fibre formed of short, interannular segments, arising from the constriction, and penetrating into the sheath of Schwann, in order to reach the cicatrix.

Sometimes it is an amyelinic axis-cylinder which appears, soon dividing into a Y, and each of its branches being surrounded with myelin, and giving origin to two nerve-fibres. At other times three myelinic fibres are appended to the convexity of the same constriction. Finally, the same nerve-fibre, by a series of dichotomous divisions, may produce twenty, thirty, or forty new fibres.

These fibres penetrate into the cicatricial segment, where they appear, colored by osmic acid, as a skein of tangled threads. The nerve-fibres, when separated, form a considerable number of small fasciculi, or are mingled in varying number with fibres of Remak and myelinic fibres. The latter become more numerous as the time of section becomes more distant; but it cannot be admitted, according to Ranvier, that there is a transformation of Remak's fibres into myelinic fibres.

Finally, when the peripheral segment is examined by dissection, there are seen among the sheaths of Schwann, completely emptied and folded upon themselves, other sheaths containing in their interior one, two, or even ten or twelve myelinic fibres of new formation. These new fibres are formed of very short interannular segments, each provided with a nucleus; they then constitute perfect nerve-fibres, but excessively small. All these new fibres are not contained in the old sheaths of Schwann; some penetrate into their interstices, rolling themselves around them, or spreading out freely, sometimes in rectilinear fasciculi with more or less frequent Y divisions, and sometimes in a confused and inextricable network.

Thus, according to both Ranvier and Waller, the regeneration of nerves is due to a budding of the nerve-fibres remaining in connection with the centres, the fibres of new formation traversing the cicatrix in order to reach the peripheral end, where they are developed either in the interior of the old sheaths of Schwann or in their interstices.

The *duration of this process of repair* is very variable. In the rabbit, the regeneration begins as early as the twentieth day. But it is only about the beginning of the third month that the effects are sufficiently well marked to be successfully studied; the repair is complete about the beginning of the sixth month.

The above are the phenomena produced in animals as the result of a simple section. Is it the same with nerve-wounds in man? This is very probable, if the wound is clean-cut, if the nerve-ends are but little separated, and if neither attrition nor very violent inflammation results from the traumatism. Neuritis, however, is not as rare an occurrence as it has been deemed. It is evident that if the interfascicular tissue of the nerve become inflamed, the process of regeneration will be inevitably arrested. Now there are cases in which the proliferation of the connective-tissue elements in the interstices of the nerve-fibres becomes very abundant, and there may result a true cirrhosis of the nerve. It is very important that this epineuritis, described by Erb, should be recognized; if it only affects the peripheral end, it is even then very grave, since it entirely or partly prevents the re-establishment of the functions of the nerve; if it extends to the central end, and ascends towards the centres, it may have consequences to which we shall have occasion to refer hereafter.

Functional and Trophic Disturbances Consecutive to Injuries of Nerves.—Among the disturbances which follow traumatisms of nerves, there are two great classes to be distinguished. In the first, we place the symptoms which are the direct consequence of the nerve injury, and which result from the separation of the nerve from its central connections: these are *peripheral disturbances*, properly speaking; in the other we place the re-

mote phenomena, the *phenomena of irradiation*, which are dependent upon the reflex effect of the injury upon the nerve-centres. The symptoms of the first class are evidently dependent upon the alterations undergone by the peripheral end, degeneration of nerve-fibres, and, in certain cases, more or less marked interstitial inflammation. The pathogeny of the disturbances of the second class is more obscure; they are attributed to the ill-understood modifications which occur in the central end, and which may extend to a greater or less height, and even to the nerve-centres themselves.

I. Peripheral Disturbances.—To this group belong the disturbances of sensibility, motility, and nutrition, which are observed in the territory of the injured nerve; we will study them in succession.

(1) *Sensory Disturbances.*—The first symptom experienced in consequence of an injury of a nerve is an acute *pain*, the characters of which vary; sometimes there are shooting pains, radiating along the whole course of the injured nerve; at other times there are smarting sensations, numbness, or tingling. In gunshot wounds the pain may be absent, perhaps overlooked in the special conditions of excitement in which the wounded are placed. In ninety-one cases recorded by Weir Mitchell, more than one-third of the patients had felt nothing at the moment of injury.

Be this as it may, this primary pain should be distinguished from the phenomena of hyperæsthesia which supervene at the end of a certain time, and which Weir Mitchell has admirably described under the name of *causalgia.* The sensation of *burning pain* which constitutes causalgia, is of an extreme intensity; patients compare it to the pain produced by a sinapism, a blister, or a red-hot iron, applied upon the denuded derm. This pain occupies as its seat of predilection the palmar surface of the hand, and the dorsal surface of the foot; it is generally accompanied by a glossy condition and a redness of the skin, which belong to the class of nutritive disturbances. The affected parts are exquisitely sensitive; the least touch, or the slightest grazing, awakens the sensation of burning and provokes a paroxysm of atrocious suffering. Weir Mitchell attributes the causalgia to an alteration of the extremities of the sensory fibres, due to disturbances of the circulation and nutrition consecutive to the irritation of the injured nerve. But it must not be forgotten that causalgia is observed in neuritis, properly so called—in the brachial neuritis, for example, of cervical Pott's disease. In the causalgia, then, which follows traumatisms of nerves, especially if this causalgia be accompanied with lancinating pains, a true inflammation of the injured nerve-trunk may be thought of, rather than simple circulatory disturbances of irritative origin.

The hyperæsthesia may be slight, when there are observed, at the same time, tingling, numbness, and formication, along the course of the injured nerve, especially in cases of contusion or compression. If temporary, these disturbances have no great importance; if they persist, or if they become exaggerated, and complicated with darting pains, the development of an interstitial neuritis must again be dreaded.

Even in cases where this exaltation of painful sensibility exists, there is at the same time a notable diminution of the tactile sense. *Anæsthesia* is, in fact, the most constant consequence of nerve-sections. But the distribution as well as the degree of this anæsthesia is very variable. It would appear that, after the section of a nerve, the sensibility should be completely abolished in all the region supplied by that nerve; but this is far from being always the case.

In the first place, sensibility may not be destroyed in all its manifestations:

thus cases have been noted, in which sensibility to pain was abolished, while tactile sensibility persisted. Tripier refuses to credit the authenticity of these cases; but sensibility to temperature may be totally suppressed, while tactile sensibility and sensitiveness to pain continue more or less perfect.

*Thermo-anæsthesia* is the most constant and best marked phenomenon which results from lesions of nerves. Patients do not feel the burning produced by a match, but perceive the prick made by a pin. As to tactile sensibility, if it is examined by means of Weber's compass, in cases of complete section of the nerve, it is, according to Tripier, always impaired; never has he seen, in such a case, the patients able to feel both points of the compass, whatever their separation, though they feel punctures more or less clearly.

Let us next inquire what is the distribution of this anæsthesia. During the first moments which follow the traumatism, it is difficult to appreciate with exactness the state of the sensibility, the condition of the patient rendering it inadmissible to trust with entire confidence to his replies. It is, however, probable that the complete section of a nerve has always as an immediate consequence the loss of sensibility in the territory supplied by the nerve. At a later period, one of two conditions may be presented: either the anæsthesia persists, thus limited—and these are the most common cases; or else sensibility reappears after a variable time, in the zone innervated by the divided trunk. The first examples cited of this rapid re-establishment of the sensibility, after ten, fifteen, or thirty days (cases of Béclard and of Paget) were explained by a secondary reunion of the parts of the divided nerve, more prompt than was ordinary. The case of Laugier, in which the sensibility reappeared some hours after suture of the two ends of the median nerve, might lead to a belief in the possibility of immediate reunion. But the case published a few years afterwards by Professor Richet does not admit of this interpretation. Twenty-four hours after section of the median nerve at the lower part of the forearm, before the use of any suture, sensibility existed in the entire hand, with the exception of the palmar surface of the last phalanges of the forefinger. This anomaly could only be explained by the existence of anastomotic or recurrent filaments.

The investigations of Arloing and Tripier have, in the opinion of Professor Vulpian, definitively established this point in science. In operating upon dogs and cats, these physiologists have ascertained that it is impossible, in the upper extremity, to mark out the portions of skin which, from a functional point of view, would be under the control of the ulnar, the median, or the radial nerve. The areas of distribution of these nerves encroach more or less upon each other. As long as a nerve-trunk remains, connecting the extremities of the limb with the nerve-centres, sensibility persists, more or less weakened. Arloing and Tripier have demonstrated that this fact is explicable by the existence of true recurrent fibres, which are mutually sent to each other by the different nerves; the recurrence of these fibres occurs principally in the neighborhood of the skin, or in its thickness, where they form a part, more or less, of the peripheral network, and then reascend along the different trunks to spend themselves and disappear at a certain height; these fibres remain intact at their peripheral end, while the direct fibres undergo the Wallerian degeneration.

These experiments, as the authors recognize, are not directly applicable to man, the distribution of the nerves not being the same as in the cat or in the dog; by analogy, however, they permit a satisfactory explanation of cases similar to that of Professor Richet.

(2) *Motor Disturbances.*—*Muscular paralysis* is the natural consequence of section of a nerve. May it too be wanting, like anæsthesia? May there be a

substitution of motility (*motilité supplée*, of Létiévant)? Some cases of this kind have been reported, but they must be received with great hesitation. Those cases only in which examination of the electro-contractility has been carefully practised can be considered as convincing. If, indeed, the observer is contented with making the injured person execute voluntary movements, it is quite possible that these will appear only slightly embarrassed. As Tripier remarks, if a single nerve has been injured, error may readily arise from observing the action of those muscles, the nerves of which have not been cut, and which, in the normal state, take more or less part in the execution of the same movements as do those, the nerve-supply of which has been interrupted.

*Muscular hyperæsthesia*, transient clonic or tonic *spasms*, and a kind of *fibrillar contraction* (Weir Mitchell), have been described in the muscles innervated by the injured nerve. "In certain cases," says the American author, "the nerve wound, in place of causing primary loss of mobility, occasions either sudden muscular contraction, followed by instant loss of power, or, in very rare instances, long-continued spasm. A soldier, wounded in the brachial plexus, at Antietam, was obliged to ask a comrade to unclasp his rigid fingers from their hold upon the musket." But these phenomena are rare, and it is not necessary to dwell upon them further.

The most interesting point is the study of the *electro-contractility*. Until within the last few years, most physiologists asserted that, after the section of nerves, the electro-contractility persisted almost indefinitely in the muscles. The researches of Barwinkel, Erb, and Biernssen, have made known new facts which it is important to notice. These researches have related especially to the influence of galvanic currents, and the conclusions to which they have led are sufficiently exact for physicians to hope to obtain great advantages, both from a diagnostic point of view and from that of the prognosis of nerve lesions.

When a nerve has been cut, in an animal, there is produced as in man a motor paralysis, and in time an atrophy of the muscles. In these conditions, the examination should be made with the aid of continued and interrupted currents; it should be directed to the nerve itself and to the muscles.

Let us first see what takes place in the examination of the *nerve*. In the case of a section, or of a complete crushing of the nerve, it is found that faradization and galvanization give identical results; the electric reaction rapidly diminishes; before the end of the first week it is entirely absent; the excitability of the nerve is abolished for both kinds of currents. If recovery is going to occur, and if regeneration of the nerve is taking place, the excitability gradually disappears; at first feeble, it rapidly increases and returns to the normal condition.

When the *muscle* is examined, the course of affairs is different. During the first fifteen days, the *faradization curve* becomes gradually depressed. After the third week, the muscle is no longer excitable, at least through the skin. Toward the sixth week, in favorable cases, the excitability reappears, and gradually increases until it reaches the normal reaction. But the *galvanization curve* follows an entirely different course. During the first fifteen days, it follows the faradization curve, but from the third week, when the interrupted currents have no longer any effect, the galvanic reaction is exaggerated, the curve is raised, soon exceeding the normal, and reaches its maximum when the other is at its minimum. This is what the Germans call the *reaction of degeneration*. At the moment that repair begins to take place, the phenomena follow an inverse order; at the same time that the faradic curve is raised, the galvanic curve is lowered, and both gradually return to the normal level.

If, instead of a favorable case, we suppose a case in which the regeneration of the nerve does not occur, there is no ascent of the faradic curve, and the galvanic curve, after being elevated, falls again to the normal, and then continues to sink until the reaction becomes null; the excitability of the muscle and of the nerve is then abolished for ever.

Do the same phenomena occur in man, as in animals which are made the subjects of experiment? Precise observations are not sufficiently numerous to permit this fact to be definitively affirmed. It is not to be forgotten that Professor Vulpian has called in question the certainty of the reaction of degeneration. A minute study of these electric phenomena in the traumatisms of nerves, is then necessary before we can apply in all certainty to man the results observed in animals.

(3) *Nutritive Disturbances.*—I do not purpose giving here the history of the general question of trophic disturbances of nervous origin. Limiting myself to that which concerns lesions of the nerves, I will say that Professor Charcot published, in 1859, the first observations of herpes zoster, consecutive to a traumatic nerve-lesion. A few years afterwards, the writings of Paget, in England, and especially the remarkable work of Drs. Mitchell, Morehouse, and Keen, in America, made known most of the nutritive alterations which may be determined by a nerve wound. The names of Brown-Séquard, Samuel, Vulpian, Mougeot, and Couyba, are also connected with this question, and it will suffice to have mentioned them before beginning the enumeration of the various disturbances which it is proposed to study.

I shall first describe the *cutaneous lesions*, as they are also the first to attract attention. These lesions are very variable; we may see them ranging from a simple, smooth redness of the skin, to deep alterations of the derm, without being able to explain by a distinct cause the diversity of these manifestations. All that is known, is that the effects vary according as the section of the nerve is complete or incomplete. This is a fact upon which the American surgeons have with reason insisted. The cutaneous lesions, as well as the other trophic disturbances, are especially observed in cases of incomplete section.

A *glossy redness* of the skin, with or without bullous elevations of the epiderm, is one of the most frequent phenomena. It has been variously named "glossy skin," "eczematous eruption," and "erythema." The skin of the fingers, according to Paget, is smooth and shining in the most marked cases; the affected fingers are ordinarily tapering, glossy, hairless, devoid of wrinkles, and shining, with a more or less deep-red color, uniform or in patches, as in chilblains. This glazed redness occupies the fingers, the palmar surface of the hand, and the dorsal surface of the foot. It is ordinarily accompanied by violent neuralgic pains, and by the very painful burning sensation which has already been mentioned under the name of causalgia.

The redness may exist alone, but more often it is complicated, as in a burn of the first degree, with the formation of larger or smaller *phlyctænæ*. At times these are small vesicles, disseminated or in groups; sometimes large bullæ, which raise the epiderm over the limits of the erythematous redness. These bullæ, filled with a lemon-colored serum, may rupture and leave the derm exposed, leading to the occurrence of persistent ulcerations, and to an increase of the smarting pains.

The *pemphigoid eruptions* still more frequently give rise to the formation of obstinate ulcers; they are rapidly developed, generally upon the fingers. The fluid which they contain is serous, sero-sanguinolent, or sero-purulent. When the epiderm ruptures, there remains a more or less deep *ulceration*, which is ordinarily very long in cicatrizing.

Trophic changes (Glossy skin and Turtle-shell Nails)
following injury to nerves of forearm
(From a patient of Dr Wr Mitchell of Philadelphia)

*Herpes zoster* forms a separate class in the eruptions of this kind. While the glossy skin appears to be peculiar to traumatisms of nerves, herpes zoster appears here with the characters which are habitual to it, either in spinal affections or in cases of spontaneous neuritis. There are isolated groups of vesicles, which appear upon red patches separated by intervals of healthy skin, and which are distributed along the course of the injured nerve. It is useless to dwell upon the evolution of these vesicles, which terminate by desiccation, as in non-traumatic herpes zoster, but which may also, although rarely, be complicated with ulceration or limited gangrene. Professor Verneuil has distinguished three varieties of *traumatic herpes:* (1) herpes which appears along the course of the nerve, below the wound; (2) herpes of proximity, which occurs in the neighborhood of the wounded nerve; (3) remote herpes, which occurs far from the seat of the injury, as the result of a kind of reflex irritation.

I have said that the bullous and pemphigoid eruptions frequently terminate in obstinate ulcerations. These ulcerations may occur even without a preceding eruption. To this category it has been proposed to refer the affection known as "perforating ulcer of the foot." While it is true that frequently the occurrence of a perforating ulcer is singularly favored by the previous existence of trophic disturbances of nervous origin, this affection is not met with unless a local compression intervenes, as has been demonstrated in the theses of two of my pupils, Soulages[1] and Butruille.[2] It is not the same with the ulcerations which may appear on the surface of the toes in consequence of sections of the sciatic nerve or of its branches; in these cases the intervention of compression is not necessary, just as in the ulcerations of the extremities of the fingers which result from section of the median nerve.

To these lesions which affect the derm, are joined various alterations of the epiderm, or of its appendages, the hair and the nails. Its thickening, its yellowish or brownish discoloration, and its desquamation in small dry scales, which are slow to separate, are the modifications of the *epiderm* pointed out by Weir Mitchell and by Couyba. The *hairs* come out in the regions where the glossy skin occurs, though at times they are found increased in number and lengthened in cases of painful irritation. As to the lesions of the *nails*, it is again to Weir Mitchell that we are indebted for their best description. The nails may become thick and club-shaped, or, on the other hand, may undergo atrophy, becoming dry, scaly, and brittle. At other times they are curved like turtle-shells, blackened, and, as it were, elevated by the hypertrophy of the subjacent tissues; the matrix is separated from the nail and becomes ulcerated. Sometimes the nails present an antero-posterior incurvation; sometimes they are rolled up transversely, and then become very painful; finally they may be completely shed, and then grow again unevenly.

[By the great courtesy of Dr. Weir Mitchell, the editor is permitted to have reproduced here the accompanying illustration (Plate XVII.) of the trophic changes in the skin and nails following nerve injuries. Dr. Mitchell's original paper will be found in the Transactions of the College of Physicians of Philadelphia, 3d series, vol. ii., p. 115.]

In connection with these nutritive disturbances of the skin, must be mentioned the modifications of secretion and temperature which have in some cases been observed. According to Weir Mitchell, *the secretion of sweat* may be abolished after complete section of a nerve; it is increased in incomplete sections with irritation.[3] In other cases the sweat has a very marked acid smell, especially in cases of causalgia.

[1] Thèse, Paris, 1875. [2] Thèse, Paris, 1878.

[3] Often, in trophic disturbances of the foot, of nervous origin, I have observed the sudden profuse sweatings which appear at the moment that the foot is examined.

The *state of the temperature* in the paralyzed parts has not been much studied, except by the American surgeon. When the peripheral end is irritated, there will be a slight elevation of temperature. After complete section, at the end of a certain time, there will always be lowering of temperature. In a case of contusion of the nerves of the arm, with immediate paralysis of the muscles of the forearm and of the hand, M. Terrillon observed, twenty-four hours after the accident, a difference of over six degrees (11° Fahr.) in the temperature of the two limbs; the thermometer placed in the paralyzed hand marked only 23.9° (75° Fahr.), while in the hand of the opposite side it marked 30.5° (86.9° Fahr.). The scarcity of recorded cases does not permit further dwelling upon this part of the question.

The trophic disturbances which affect the more deeply seated tissues are, with the exception of the muscular changes, very much more rare.

The *lesions of the cellular tissue* are limited to a certain degree of *œdema* more or less marked. This œdema may appear and disappear again several times at intervals. In the end, it is possible that the subcutaneous tissue may remain thickened and indurated. Weir Mitchell has seen, following a gunshot-wound of the arm, an elephantiasis-like swelling of a portion of the hand. As to suppuration, the case reported by Couyba is the only one which would indicate the possibility of this termination.

The lesions of the bones and articulations are not much more common; at least the published cases are few in number. The principal characters of the *arthropathies*, or joint-diseases consequent upon secondary nerve-injuries, are: a painful swelling, which may attack one or all the joints of the limb; a slight redness around the articulation; extreme sensibility of the affected joints; and, finally, persistent rigidity, with a semi-anchylosis which resists all treatment. "When the acute stage has disappeared," says Mitchell, "the tissues around the articulation are indurated, and there results a partial anchylosis." These joint-inflammations appear a certain but variable time after the traumatism, and are accompanied by the other disturbances which we have noted as affecting the skin, and sometimes by a more or less extended inflammatory œdema. The joints in the part supplied by the injured nerve are alone involved. Microscopic examination of the articulations thus affected has rarely been made. In a case published in the *thèse d'agrégation* of Blum, the histological study of the parts, in a man who died seven years after a complete section of the median nerve, showed that the cartilages of the diseased articulations were softened and thinned, and presented a marked cellular proliferation; the bones were rarefied and likewise thinned, the compact layer also being diminished in thickness.

The few examples known of *osseous lesions resulting from nerve-wounds* have been collected by W. Ogle. Cases of *necrosis* following accidental or operative nerve-wounds have been recorded, but the most frequent lesion appears to be *atrophy* of the bone. I have already mentioned Blum's case. Lobstein observed a remarkable instance of atrophy of the femur, in a man who, when a child, had received a serious wound of the thigh, involving the sciatic and crural nerves. In another case of Ogle's, in consequence of a wound of the median nerve, the ulna and radius were found united at their lower part by an osseous deposit; there was an extremely marked atrophy of the bones of the hand, which had preserved their shape, but had become very light and transparent.

The different trophic disturbances which have been enumerated are not a necessary result of traumatic nerve-lesions; on the contrary, the *muscles* to which the cut nerve is distributed inevitably undergo, after a certain time, the alterations which will now be described. This is easily explained with the view that is now held as to the relations of muscular fibre with the nerv-

ous system. According to Ranvier, according to Professor Charcot, the motor cell of the anterior cornua of the spinal cord, the axis-cylinder which is thence derived (and which extends, surrounded by myelin, as far as the terminal plate), and finally the muscular fibre, form a continuous whole intimately united, to which the name of neuro-muscular system may be given; the nerve-cell is, through the terminal plate, directly imbedded, as it were, in the muscle-cell. Every degeneration of the axis-cylinder must then inevitably react upon the muscle-cell.

We have seen that as early as the seventh day after section of a nerve the destruction of the axis-cylinder is complete; the nerve no longer exists. It is at this moment that the *alterations of the muscle* begin to appear. The first changes are in the muscular nuclei, which proliferate and form chaplets; the intimate substance of the muscle remains normal, preserving its striated aspect; there is not, as was formerly believed, a granulo-fatty degeneration. But the muscular fasciculus undergoes a diminution in size, a very rapid emaciation. At the same time there occurs a connective-tissue proliferation of the peri-mysium, whence an exaggerated formation of interstitial tissue, which incloses, and, as it were, chokes the muscular fibres. During the second month, when regeneration of the nerve is taking place, these alterations disappear, and the muscle returns to the normal state. But if regeneration does not occur, the lesions progress indefinitely and lead to irreparable atrophy. At the end of ten or twelve months, the muscular substance is represented only by small and extremely slender fasciculi, which preserve to the last their striation. *Interstitial cirrhosis* gains the ascendency, there is a rudiment of muscle enveloped by a mass of fibroid connective tissue, sometimes loaded with fat vesicles. This deposit of fat may be exaggerated, giving rise to the condition which the Germans call *luxuriant lipomatosis*, and it can be understood that this excessive development of fat may give to the really atrophied muscle an appearance of normal size.

Muscular atrophy is then the inevitable consequence of the section of a nerve—reparable, if the nerve is regenerated, irreparable if there is permanent destruction of the nerve trunk. Does it as necessarily result from a simple section as from an irritation of the nerve? It is known that Brown-Séquard had established a capital distinction between the effects of irritation and those of simple suppression of nerve action. Charcot, who had applied this distinction to the interpretation of the different trophic disturbances, and had accepted without restriction the theory of Brown-Séquard, has recurred to this point in the second edition of his book, and with some reservations. These are rendered necessary by the results furnished by examination of muscles after nerve lesions. The experiments of Vulpian, of Neumann, and of Eichhorst, prove that muscular atrophy is constant whenever the continuity of the axis-cylinder is interrupted. The effects of the cessation of nerve-action, then, do not differ here from those of irritation. Is it the same for articular and cutaneous trophic disturbances? I shall not attempt to decide this delicate point. What it behooves us to remember, is that, clinically, the consequences of simple nerve sections are certainly not the same as those of wounds with irritation. Every one agrees, in regard to this matter, that the observation of Weir Mitchell is absolutely true, namely, that the trophic disturbances from nerve-wounds are especially developed in consequence of incomplete sections, of contusions, of punctures—of causes, in a word, which determine an irritation of the nerve—and that a simple division of the nerve-trunk does not, as a rule, entail similar consequences. This leads us to speak of the influence of nerve-sections upon the phenomena described under the name of neuro-paralytic inflammation. But first I will terminate what has reference to the lesions of the muscular system, by saying that I have seen a

gunshot wound of the radial nerve followed by a swelling of the back of the hand, due to a trophic disturbance of the extensor tendons and their sheaths.[1]

(4) *Neuro-paralytic Inflammation.*—The types of this kind of inflammation are furnished by the broncho-pneumonia consecutive to section of the pneumogastrics, and by the alterations of the eye which follow section of the trifacial. Experiments made upon animals have demonstrated that section of the tenth pair determines a passive congestion of the lungs, œdema, emphysema, nodules of hepatization, and an intense inflammation of the bronchial mucous membrane. Again, when the trifacial is cut within the cranium, the conjunctiva becomes inflamed and secretes a puriform mucus; the iris becomes red, and is covered with false membranes; the cornea, after the first twenty-four hours, begins to look cloudy, and at the end of five or six days becomes of a milky whiteness from plastic infiltration and the formation of crystals of carbonate of lime; the pituitary mucous membrane becomes spongy and bleeding; and ulcerations occur upon the lining membrane of the lips. These phenomena, first described by Magendie in 1824, have been verified by all physiologists. But their interpretation has given rise to animated discussions, and unfortunately, as we shall see, a satisfactory explanation yet remains to be given.

Three principal hypotheses have been suggested: (1) Is there a modification of vaso-motor action? (2) Does the nerve section suppress, or does it irritate, certain fibres with special functions, called nutritive or trophic? Or (3), finally, does it only play a secondary part by favoring the action of external traumatisms?

Every one knows the celebrated experiment of Pourfour du Petit and of Claude Bernard. Section of the sympathetic nerve in the neck produces a vaso-motor paralysis, with redness, elevation of temperature, and swelling of the paralyzed parts. These are phenomena which are very analogous to those of inflammation; but nevertheless it cannot be said that there is an inflammatory lesion. Every one acknowledges at the present day that vaso-motor paralysis determines a simple fluxion, and is not capable of producing a true phlegmasia. The parts attacked are in imminent danger of inflammation, so to speak; a phlegmasic predisposition is created; but in order that inflammation should be developed, the intervention of an accessory cause, mechanical or chemical, is required. As regards the lung, it is not even necessary that this vaso-motor paralysis, admitted by Schiff and Genzmer, should intervene. Professor Vulpian has demonstrated that neither section nor electrization of the vagi modifies in any way the color of the respiratory mucous membrane. According to M. Vulpian, the vaso-motor nerves of the lung are contained in the filaments of the sympathetic nerve, and not in the trunk of the pneumogastric.

Ought we to admit a direct trophic influence? Traube and Steiner deny such an influence. According to them, the pulmonary lesions are due to the accompanying paralysis of the muscles of the larynx; the entrance of particles of food into the bronchi irritate the anæsthetized and defenceless mucous membrane, and this traumatic irritation is the real cause of the inflammation. It must be said, however, that Traube's hypothesis does not explain all, since Genzmer and Michaelson have obtained the same results, the same broncho-pneumonic lesions, by cutting the vagi below the recurrent, so as to avoid laryngeal paralysis, and the consequent entrance of particles of food. These authors admit that the lesions are due to vaso-motor paralysis; but, as we

[1] Gazette Médicale, 1873, p. 458.

have said, the vaso-motor nerves of the lung do not seem, according to the experiments of Vulpian, to be contained in the pneumogastrics. It is therefore impossible to decide this question.

Do the experiments made upon the trifacial lead to a clearer interpretation of the observed changes? Here again the paralytic congestion due to section of the vaso-motor nerves contained in the trifacial does not explain the inflammatory lesions, since section of the sympathetic itself determines a much more marked congestion without nutritive disturbances. This congestion, then, cannot be considered but as a predisposing cause.

The hypothesis of a direct trophic disturbance has more partisans. But do there exist in the trifacial nerve any special trophic fibres, or, on the contrary, is the nutritive influence common to all the fibres of the nerve trunk? On the other hand, are the lesions due to a destruction or to an irritation of these fibres?

Meissner and Merkel admitted that the trophic fibres of the trifacial were contained in the internal part of the nerve-trunk. There would be no disturbances of the eye if this internal part were avoided, and if only the external part were cut. Inflammatory disturbances would then be produced by the suppression of certain fibres of the trifacial. Samuel, on the contrary, thinks that these phenomena are caused by irritation of the cut nerve. By thrusting two needles into the Gasserian ganglion of a rabbit, and passing through these needles an induced current, for some time, he caused the development of the same phlegmasic lesions of the eye. This experiment seems unsatisfactory to M. Vulpian, on account of the situation of the Gasserian ganglion, and the difficulty of being certain that the ganglion alone is involved. The trophic disturbances observed in man as a result of neuralgia or neuritis of the trifacial, would seem, however, favorable to Samuel's hypothesis. But the complexity of clinical observations scarcely permits, according to Vulpian, of their being invoked in support of any particular hypothesis in a discussion of this kind.

There remains the hypothesis of external injury. Snellen and Buttner have shown that if, after section of the trifacial, the eye is protected, either by means of the ear, which remains sensitive through the action of the cervical nerves, or by means of a thick piece of leather, there is no alteration of the cornea at the end of six, eight, or even ten days. Eberth, relying upon these facts, explains the ocular lesions and the keratitis by the action of micrococci in the air which lodge and multiply upon the cornea, which is anæsthetic, and deprived of the power of resistance by the suppression of its nerve filaments.

It is thus seen that no more light has been thrown upon this side of the question than upon the pulmonary alterations consecutive to a section of the vagi. "It seems certain to me," says Prof. Vulpian, "that these disturbances of nutrition are due neither to an irritation of the cut nerve-fibres nor to a paralysis of the vaso-motor fibres contained in the nerve; but after eliminating these suppositions, we find ourselves in the presence of hypotheses upon the value of which we have no sufficient information." If the experiments of Snellen are to be trusted, the contact of foreign bodies is the determining cause of the alterations, the vaso-motor paralysis creating conditions favorable to the development of inflammation.

This also seems to be the true explanation of the cases of inflammation with ulceration which are observed as the result of sections of the peripheral nerves, of the sciatic, for example. In this case, the part played in the production of the ulcerations observed in animals by pressure of the foot upon the ground, or of the bones upon the soft parts, does not appear questionable.

And it is thus, no doubt, that must be explained the frequency with which perforating ulcers are developed in consequence of injuries of the sciatic nerve in man.

Still, it is far from being the case that the external injury, in connection with the vaso-motor paralysis, is sufficient to account for all the inflammatory disturbances consecutive to nerve lesions. Without speaking of the eruptions and glossy skin, the joint inflammations do not seem to be explicable in this way.[1] There is here very probably a direct action exercised by the nervous system. But it must be confessed that the nature of this action is unknown. Is there a diminution of the trophic influence of the nerve centres, as admitted by Vulpian? Is there a perversion in the way of exaggeration of this nutritive influence, as maintained by Brown-Séquard? The question remains unsettled.

II. Disturbances from Central Irritation.—Thus far we have studied the morbid disturbances which are produced in the peripheral domain of the injured or divided nerve. But it is not only in the periphery that the influence of the nerve lesion is felt. Although more rare, the *alterations of the central end* and the consequences which they may have upon the cerebro-spinal axis itself are none the less indisputable. Here again physiology furnishes an important contribution to the question, and the results obtained by experiment may serve as a foundation for the description of clinical facts.

It is to Tiesler, Feinberg, Klemm, Niedieck, and Hayem, that the most conclusive experiments are due. These authors have shown that an injury, and especially an irritation, of the peripheral part of a nerve, determines in it changes which in a great number of cases are propagated even to the spinal cord. The contradictory experiments of Roessingh, of Rosenbach, and of Vulpian, show that this propagation is far from being constant; but they do not impair the value of the positive results established by the first-named investigators.

The *ascending neuritis* which follows the irritation of a nerve trunk is a *disseminated neuritis* (Klemm); it invades the tissue of the nerve in an irregular manner, and is particularly observable at the points where the arterial vessels penetrate the sheaths of the nerve trunks. This neuritis is above all *interstitial*. But Hayem, in his experiments, has also noted a *parenchymatous neuritis;* he has seen the axis-cylinders swollen, moniliform, and in a state of granular degeneration, with proliferation of the cells of the interannular segment. "The path of transmission of the irritation from the nerve to the spinal cord," he says, "is twofold: it is effected by the interstitial tissue, and also by the axis-cylinders, which are found swollen and moniliform in the central end of the nerve."

The consequences of this *irritation of the spinal cord* have been either lesions of the membranes—*pachymeningitis* and *meningitis*—or lesions of the medullary substance itself. Meningitis is nearly constant; myelitis is more rare; it occurs like neuritis in disseminated foci, and may ascend very high, even to the medulla oblongata. With the microscope are found all the lesions of myelitis, softening of the cord, disorganization of the gray substance, destruction of the large cells of the anterior cornua, swelling and disintegration of the axis-cylinders, and multiplication of the elements of the neuroglia.

These experimental facts, upon which I do not intend to enlarge, and which it suffices to have mentioned, permit us to understand and to explain certain symptoms, uncommon indeed, but which occasionally follow injuries

[1] The pressure of the cartilages one against the other might, however, be given as an explanation.

of nerves, and which have evidently for their cause, irritation of the central end of the injured trunk.

These disturbances from central irritation may affect both sensibility and motility. The principal sensory disturbance is what is called *traumatic neuralgia.* This neuralgia, which is also observed after amputations, occurs especially in cases of *puncture* or of *gunshot wound*, or when a *foreign body* remains imbedded in the nerve. The graphic description of these phenomena given by Professor Trélat, in a case of *neuralgia of the stump*, may serve as a type for other cases. "Touch," he says, "lightly, with the end of the finger; brush the skin of the stump; and immediately the drama bursts forth in all its violence; the patient raises above the bed, with a sudden, automatic movement, the lower limb, which is immediately seized with a jerking, convulsive and involuntary trembling; his countenance, at the same time, expresses excruciating pain; it becomes pale and distorted; drops of sweat form upon his forehead; and with both hands he strives to compress his thigh, to hold his limb steady, and to overcome the trembling and the darting pain. It is no use; the paroxysm persists one or two minutes, and then all becomes calm until a new touch comes to reawaken the pain." The patient compares the pain which tortures him to that of a recent burn; it seems to him that a thousand redhot needles are passing through his limb. Shooting pains radiate towards the periphery, and, at the same time, ascend towards the root of the limb. The pain may extend even to other nervous branches, more or less distant, and may affect the nerves of the limb of the opposite side. M. Ollivier has seen, following a contusion of the fifth, right, intercostal nerve, radiating pains in all the branches of the brachial plexus of the same side. Numerous examples of these *radiating neuralgias* may be found in Swan's treatise. Weir Mitchell admits in these cases an inflammation propagated from the injured nerve to the other branches by means of anastomoses. Professor Vulpian thinks, on the contrary, that if occasionally these neuralgias may be referred to a peripheral neuritis, it is probable that they often have, at least in part, another mechanism, and that they depend upon a modification of the gray substance at the level of the medullary centre of the injured nerve.

These traumatic neuralgias are ordinarily coincident with the phenomena described under the name of causalgia, and if causalgia is often limited to the territory of the injured nerve, it may also extend to that of the neighboring branches; there is then observed that condition of excessive hyperæsthesia which Weir Mitchell has named *sensory tetanus.* According to the hypothesis of Professor Vulpian, the irritation in these cases would be localized in the sensory, medullary centre of the nerve. But more frequently it affects also the motor centre, and, at the same time, with the neuralgia, there are observed *traumatic spasms.* These two phenomena were united in M. Trélat's patient whose history has just been cited. These spasmodic movements, especially frequent after amputations, constitute the *chorea* or *epilepsy* of stumps, and, like the pain, the spasmodic contraction may extend to distant parts. In several of Weir Mitchell's cases, the convulsive, motor excitation was seen to extend from the muscles of an arm stump to those of the neck, trunk, face, and larynx.

It is readily understood that if the irritation becomes generalized, there follows a true *epileptic attack.* The experiments of Brown-Séquard upon the epilepsy of guinea-pigs, following sections of the sciatic nerve, are well known. Cases of the same kind have been observed in man, as the result of contusions, gunshot wounds, and other grave traumatisms of the sciatic nerve. Billroth, Schaffer, Magnan, Samuel, and Wilks, have seen attacks of complete epilepsy thus produced, the initial aura having its origin from

the injured nerve. Swan, Hamilton, and Féron have described analogous facts in cases of injury of the fingers. Larrey relates that in consequence of a prick of the internal cutaneous nerve at the bend of the elbow, in a soldier, paroxysms of epilepsy supervened. The patient felt an acute pain at the level of the cicatrix, followed by a distressing shudder, which passed up the course of the nerve, on the inner side of the arm, towards the head, when convulsions immediately ensued. Wilks and Weir Mitchell have published several similar cases.

*Traumatic neuralgia*, *convulsive spasms* or *local epilepsy*, and *general epilepsy*—such are the consequences of central irritation consecutive to nerve injury. *Tetanus* need only be mentioned. The irritation may extend higher than the spinal cord. The observations of Weir Mitchell show that temporary *mental derangement* may be a sudden consequence of nerve injury. A volunteer, he says, received a gunshot wound in the brachial plexus; he immediately became like a madman, crying murder, and accusing his neighbors of having assassinated him. An officer, wounded in the arm, had the median nerve cut; he began to speak incoherently of subjects entirely foreign to the occasion and to the place in which he was. He was very weak, but had lost little blood; he had not the least recollection of his wound; he had forgotten all that had passed during the hour which followed his injury.

The various phenomena which have just been described are centripetal effects of injury of the nerves, without any true lesion, or at least any that is recognizable, of the nerve centres. Can there be an inflammatory lesion of the spinal cord, as in the experiments regarding ascending neuritis, made upon animals? A certain number of observations seem to establish the possibility of this result, apart from other facts the anatomical explanation of which is yet to be found. This is what now remains for us to study under the name of reflex paralysis.

Reflex Paralysis.—This form of paralysis, described by Whytt and Prochaska under the name of sympathetic paralysis, was first observed and studied in the domain of medical pathology. The observations of Stanley made known the palsies of renal origin; those of Graves the palsies of intestinal origin. Romberg added to them the palsies from uterine lesions. The question found no place in surgical pathology until the appearance of the work of Mitchell, Morehouse, and Keen. Brown-Séquard had pointed out the existence of palsies occurring at a distance under the influence of traumatisms. But it is to the American surgeons that belongs the merit of having, by exact observations, placed beyond a doubt the reality of these palsies. Since then, new observations have still further extended the field of these phenomena, and for clinical purposes it is convenient to distinguish two classes of cases, according as the spinal medullary disturbances appear immediately after the traumatism, or are progressively developed after a longer or shorter time.

According to Mitchell, reflex traumatic paralysis is a paralysis which shows itself in wounded persons, in a region distant from the wound, when the first shock of the injury has passed. He reports seven cases. In the first, a wound of the neck was followed by paralysis of both upper extremities. In Cases III. and VI., wounds of the sciatic and crural nerves led to paralysis of an arm. In Case IV., a soldier received a ball in the right testicle; there was paralysis of the right tibialis anticus and peroneus longus. In Case II., a soldier was wounded in the right thigh; he half fell, unconscious, and paralyzed in all four limbs; movement rapidly returned in the left arm, but the recovery of the three other extremities was much more

delayed. Brown-Séquard has seen an analogous case. "I was consulted," he says, "by an American officer, who, in consequence of a gunshot wound of the cervical and brachial plexuses of the right side, became paralyzed, to a slight degree, in all four extremities, but especially in the right arm and left leg." In all of these cases, in spite of the primary gravity of the phenomena, amelioration rapidly followed, and recovery gradually became complete.

Cases of this kind are rare. To Weir Mitchell's cases may be added those of Larrey. This surgeon reports, in his *Mémoires de Chirurgie Militaire*, that during the campaign in Syria, very slight wounds of the shoulder were followed almost constantly by complete or incomplete paralysis of the corresponding limb; "which never occurs in Europe," he says, "at least if the principal nerves are not cut or disorganized." He explains these palsies by lesions of some superficial branches of the cervical pairs, and attributes also a certain influence "to the asthenic and stupefying qualities of the climate of Syria;" while Weir Mitchell, connecting these palsies with the phenomena of cerebral excitement, consecutive to traumatism, of which we have just spoken, explains these cases by a kind of local determination or nervous commotion. In place of an impression upon the cardio-motor centre, there is observed only a counterstroke upon the emotional centres, upon the mechanism of ideation, upon a sensory ganglion, upon a limited group of motor cells. Why the brain should be affected in one case, the heart in another, the motor cells in a third, it is not possible to know.

The immediate appearance of paralytic symptoms in consequence of the traumatism, and their usually rapid cure, differentiate the cases of this first group from others which we may place in a second category, and in which the spinal disturbances are more tardy, being slowly developed, and having no tendency to recovery. After a wound which has more or less directly involved a nerve-branch, there appear, usually after a considerable interval of time, symptoms either of subacute myelitis, of muscular atrophy, or of locomotor ataxia.

Locomotor ataxia, it may be said at once, is rare. A certain number of cases of ataxic tabes which seem to have been developed in consequence of peripheral traumatisms, have been published, but in no case has there been a localized injury of a nerve; the lesions have been such as have involved some extent of the integument or of the limb, such as an amputation of the leg (Vulpian), chilblains (Duplay, Nicaise), and contusions. The spinal phenomena usually noted as resulting from nerve injuries are symptoms of subacute myelitis, with muscular atrophy.

One of the first cases of this kind was published by Charcot in 1856. A vigorous man had a diffused phlegmon of the left forearm, which required five incisions. One of these incisions, made over the course of a branch of the radial nerve, injured, no doubt, this nerve-twig. Soon after, the patient felt the strength of the left arm diminishing, and was seized with sharp pains, with formication—recurring in paroxysms and starting from the cicatrix which corresponded to the radial branch—with nearly complete anæsthesia, with paralysis and atrophy of the muscles, and with a bullous eruption upon the dorsal surface of the hand and fingers. During more than a year, the left side alone was affected. Afterwards, the patient experienced a sense of feebleness and numbness of the hand and forearm of the right side. Muscular atrophy gradually ensued, as well as anæsthesia. When M. Charcot saw the patient two years subsequently, the anæsthesia seemed to be extending towards the upper part of the limb.

This case may serve as a type; the course followed by the symptoms in this case is that observed in all that have been published. Pains appear first in

the region of the injured nerve—pains which are generally violent, paroxysmal, and accompanied with formication, tingling, and sensations of smarting and burning. These pains may be accompanied with various trophic or vaso-motor disturbances, such as reddish or purplish coloration of the skin, lowering (Vulpian) or elevation of temperature (Hayem), local hyperidrosis, ulcerated panaris, bullous eruptions, etc. At the same time the limb is weakened, and the muscles are atrophied.

These phenomena may be confined to the injured limb, as in the cases of Bourke, Schwahn, Vulpian, and Hayem. In other instances they extend, as in the case of Charcot, to the opposite limb. Leyden, Vulpian, Terrier, and Le Dentu, have reported cases of this kind. But in these cases there were traumatisms very much more grave and more extended than in that of M. Charcot; large and deep burns in Vulpian's and Terrier's cases, and a penetrating wound of the knee in that of Leyden.

The extension of the symptoms may be even more considerable, as is proved by the already classical case of Barlow, and by the cases of Poncet and Heurtaux. Barlow relates that a laborer, 25 years old, gave himself a contused wound of the hand, followed by sharp inflammation, and requiring ten weeks to heal. Eventually, weakness of the hand supervened, and then of the arm. At a still later period there was complete paralysis of both motion and sensation of the entire limb. Analogous symptoms occurred in the feet, and, finally, the lower extremities became absolutely powerless and insensible. Treatment with corrosive sublimate caused some amelioration, but the patient had a fall, his condition became aggravated, his arm and his legs were again paralyzed, and he finally died. At the autopsy, the spinal cord was found reduced to a pulp in the lower cervical and dorsal regions. "It was the irritation of the peripheral nerves," says Eisenmann, in speaking of this case, "that without doubt determined, by reflex action, a stasis and softening of the spinal cord." Heurtaux's case was very analogous. Here it was a wound by a piece of bottle glass, with complete section of the left sciatic nerve, which was the origin of the symptoms. Two years after, there was complete paralysis of the left lower extremity, with muscular atrophy, and, on the right side, marked feebleness of motility and sensibility. The same functional disturbances were present in both upper extremities; the patient could move them, but without any energy; sensibility was blunted. There was incontinence of urine and of feces. At the autopsy, both ends of the sciatic nerve were found, separated by an interval of eight centimetres (3 inches +). The spinal cord was softened throughout its entire length, the softening affecting particularly the posterior columns; it was white softening without a trace of vascularization. In Poncet's case, a gunshot wound of the right brachial plexus determined a paralysis of the corresponding arm. Three years afterwards, in 1873, the left arm was already beginning to become weak. In 1875, the lesions were symmetrical in the two upper extremities. There was paralysis with atrophy of the biceps, of the brachialis anticus, of all the posterior muscles of the forearm, and of all the interossei; the thenar eminence was slightly flattened. Sensibility was abolished upon the dorsal surface of the forearm. There was, besides, atrophy of the pectoral, trapezius, deltoid, and upper part of the latissimus dorsi. The serratus magnus was beginning to be involved; a decrease in size of the glutei was recognized, and a general weakness of the lower limbs.

In all these cases it is seen that *muscular atrophy* is the constant and predominant symptom. The paralysis consecutive to injuries of nerves is eminently an *atrophic paralysis.* This peculiarity is important, for one of the most remarkable consequences of experimental neuritis propagated to the spinal cord—a consequence described by all investigators—is the rapid

atrophy observed in animals operated upon. This atrophy is in correspondence with the lesions described by M. Hayem in rabbits; the myelitis consecutive to ascending neuritis is a gray myelitis, with degenerative alterations of the cells of the anterior cornua. Now, although we do not know the spinal lesions with which the symptoms that we have been describing correspond, since hitherto no microscopic examination of the spinal cord has ever been made in these conditions, it may, without rashness, be supposed that the alterations are very analogous to those which have been observed in animals; and it is upon the constancy of the phenomena of muscular atrophy that this supposition can rest with the most probability.

If then the cause of the immediate palsies of our first group remains yet quite unknown, it may be admitted that the more tardy, atrophic palsies which are consecutive to nerve-injuries, are connected with the extension of inflammation from the injured nerve to the spinal cord, the subacute myelitis which is its consequence being sometimes localized, sometimes extending to a greater or less distance, and affecting especially the large motor cells of the anterior cornua.

## Inflammatory Lesions of Nerves.

The inflammatory lesions of nerves include *congestion* and *neuritis*.

Congestion of Nerves.—Congestion of nerves is frequent, since it is generally met with in all nerves which are involved in a focus of inflammation, and often extends beyond that focus (Cornil and Ranvier). It may be caused by traumatisms, or by excesses of heat or cold. It was experimental cooling of the nerves, that permitted Weir Mitchell and Waller to study congestion of these structures. Congestion of nerves may also follow exposure to moist cold, or to the impression of a current of air (rheumatic neuralgia).

In congestion, the nerves are slightly swollen; upon their surface are seen red lines which indicate hyperæmia of the perifascicular vessels; the intrafascicular vessels are also dilated, and there occur a serous exudation in the perifascicular connective-tissue, and often miliary hemorrhages.

The symptoms of congestion are not very definite. There are observed sharp pains, throbbing (as in cases of chilblain and whitlow), formication, numbness, hyperæsthesia, and occasionally muscular weakness. There is pain upon pressure at the level of the congested point.

We have seen that certain neuralgias, termed rheumatic, have been attributed to congestion of the nerves. We also admit the existence of paralysis *a frigore* (Capozzi), due to the reflex action of cold upon the motor nerve-fibres, a paralysis which is constantly recovered from. Certain contractions have been attributed to hyperæmia and to œdema of nerves; Jobert, Wunderlich, and Brown-Séquard, have considered congestion of nerves as the cause of tetanus.

Neuritis.—The history of neuritis is yet far from being complete. It seems that there are united under this name anatomical lesions of different causes and nature: inflammation, properly so called, with its exudates; and progressive, ascending or descending, sclerosis or cirrhosis of the nerve. Inflammation manifests itself differently, according to the tissues and organs; nerves offer to it a remarkable resistance, especially in regard to acute inflammation. Experimental investigators have ascertained the difficulty of causing acute neuritis, and the impossibility of producing ascending neuritis,

in animals. Thus the nerves retain their properties in the midst of foci of suppuration, while the perifascicular tissue is the seat of hyperæmia, serous exudation, and even diffuse suppuration (Cornil and Ranvier).

The resistance of nerves is connected with the structure of the lamellar sheath, and with the anastomoses of the vessels in the perifascicular and intrafascicular connective-tissue. This special circulation of the nerves indicates to the surgeon that he should not hasten to resect the ends of nerves, in contused wounds for example; and it also explains the possibility of denuding a large extent of a nerve (in the operation of elongation, for instance) without exposing it to mortification.

Nevertheless, neuritis is still sufficiently frequent, especially in its subacute or chronic form.

*Etiology of Neuritis.*—Etiologically considered, neuritis includes three principal varieties:—

(1) *Traumatic neuritis.* This is observed more frequently, or is more intense, after compression, contusion, puncture, and incomplete section, than after clean-cut, complete division.

(2) *Spontaneous or primary neuritis.* This is rare; it is observed after the action of moist cold, and in subjects generally predisposed—rheumatic, arthritic, etc. It may be followed by certain palsies and neuralgias; herpes zoster belongs to this variety.

(3) *Secondary neuritis.* This is very frequent and may be subdivided into neuritis by contiguity, and the neuritis of general diseases.

*Neuritis by contiguity* is developed by propagation of inflammation from organs situated in the neighborhood of the nerve: neuritis of the intercostal nerves in pleurisy (Beau); neuritis of the nerves of the extremities resulting from a focus of inflammation, an arthritis, an osteitis, or other organic lesion; neuritis in Pott's disease; neuritis after alveolo-dental periostitis; neuritis following inflammation of tendons and tenotomy (Erb); neuritis in perinephritic phlegmon, psoitis, etc.

*Neuritis of General Diseases.*—The acute infectious diseases may be followed by circumscribed neuritis: typhoid fever (Nothnagel); typhus fever (Bernhardt). Charcot and Vulpian described, in 1863, the alterations of the nerves in diphtheria; according to Buhl, the neuritis may, in this affection, reach the roots of the spinal nerves, and even the cord itself. Certain forms of poisoning may cause neuritis; poisoning by carbonic oxide (Leudet); alcoholism (Magnan); perhaps lead-poisoning (Charcot, Westphal).

Rheumatism and gout may be accompanied by neuritis; a fact which surgeons should well understand, for by appropriate medical treatment they may hope to cause the disappearance of persistent neuralgias, which otherwise they would be tempted to treat by operation. Syphilis occasions neuritis. In anæsthetic leprosy, there is, according to Virchow, a perineuritis which leads to destruction of the nerve fibres.

There remains now to be considered that peculiar, irritative process of the nervous tissues—a process of a progressively encroaching character—which leads to hyperplasia of the connective tissue and degeneration of the nerve fibres. In the case of the nerves, this process is considered as a form of neuritis; it is not, however, a true inflammation, but there is no special word to designate it, and its intimate nature has not yet been thoroughly determined.

This *encroaching neuritis* presents itself in the nerves in two forms: descending neuritis and ascending neuritis.

*Descending neuritis*, studied by Charcot, Bouchard, Cornil, and Vulpian, occurs in cases of descending sclerosis of the spinal cord, and after lesions of certain parts of the encephalon. Vulpian thus describes it: "It is known

that there is in these cases a true interstitial neuritis, which does not necessarily occasion atrophy and destruction of the nerve fibres, but which causes an increase in the size of the nerve, and is frequently accompanied by spontaneous pains along the course of the nerve-trunk, and by a state of very acute sensibility of this trunk to pressure. This lesion of nerves is observed most readily in the nerves of the extremities."

It is known that optic neuritis may be developed in consequence of lesion of the encephalon and of its membranes (Bouchut, Galezowski).

The existence of *ascending neuritis* was established by Lepelletier and Graves; it arises from the peripheral nerves, or even from the organs in which they terminate, when attacked with inflammation. This neuritis may reach the spinal cord and the nerves thence proceeding, and produce reflex paralysis.[1] It has been suggested by some authors that traumatic tetanus may be due to an ascending neuritis.

*Pathological Anatomy.*—Several varieties of neuritis may be recognized: if the inflammation remains limited to the neurilemma, it constitutes *perineuritis;* if it attacks the connective tissue which separates the nerve fibres, it is *interstitial neuritis;* finally, inflammation of the nerve elements themselves constitutes *parenchymatous neuritis* (Charcot, Pierret), with a moniliform appearance of the fibres, proliferation of the cells of each interannular segment, and disappearance of the axis cylinder. Neuritis is also distinguished as acute and chronic.

In *acute neuritis* there are observed redness and swelling of the nerve; there is hyperæmia of the perifascicular and intrafascicular vessels, and there is formed, in the perifascicular connective tissue, a serous or sero-fibrinous exudation. Miliary hemorrhages are also observed. At a later period, if the inflammation is intense, the nerve is softened, and the nerve fibres are immersed in the midst of a red, spongy tissue, and entirely reduced to a semifluid pulp.

Suppurative inflammation is rare; we have seen that the lamellar sheath offers a barrier to the pus; but in wounds of nerves, the lamellar sheath being destroyed, the suppuration can reach the intrafascicular connective-tissue (Cornil and Ranvier). Generally, after acute neuritis, the elements are regenerated, and resume their functions. The inflammation may, however, pass into the chronic state, while giving rise to a connective-tissue neoplasia.

In *chronic neuritis*, which often occurs as a primary affection, there is particularly observed a tendency to the occurrence of connective-tissue neoplasia, to induration, to sclerosis. The nerve is thickened; it presents sometimes knotty enlargements, or small tumors (fibromata or myxomata), due to a circumscribed perineuritis and often confounded with neuromata (Poincaré); it is grayish or purplish, and adheres to the neighboring tissues. Frequently the cellular new formation occupies, at the same time, the perifascicular tissue and the lamillar sheath (*proliferating*, *interstitial neuritis*); this leads to compression of the nerve fasciculi, and to their degeneration and atrophy.

The disease continuing, the nerve is transformed into a fibrous cord, hard, pigmented, and formed of connective-tissue elements. There are found at the same time the trophic lesions which accompany neuritis. This may extend towards the spinal cord.

*Symptoms of Neuritis.*—It is difficult to give a general description of symptoms applicable to all cases of neuritis, as much on account of the functional

[1] Vide supra, p. 576.

diversity of the nerves as of symptoms sufficiently characteristic of nerve-inflammation.

With Nothnagel and Labadie Lagrave, we will now study neuritis in the sensory nerves, in the motor nerves, and in the mixed nerves.

(1) *Neuritis of Sensory Nerves.*—Spontaneous pain is the principal symptom; it is sharp, lancinating, or dull, in acute neuritis; it follows the course of the nerve, and extends even into the peripheral ramifications; sometimes it takes a centripetal course; it is often continuous and without paroxysms—which would serve to distinguish it from the pains of neuralgia, if occasionally neuritis itself did not cause painful paroxysms; pain also cannot be considered as pathognomonic of neuritis in the subacute or chronic forms (Labadie Lagrave[1]). Pressure increases the pain, even when it is not applied to the inflamed point. According to Baerwinkel, the pain thus provoked has a centripetal direction; this would be characteristic of neuritis, but it is far from being always so. We should believe rather in the presence of a neuritis, if the pressure determined pain over a long extent of the course of the nerve.

Nothnagel has made an important remark, namely, that in a circumscribed neuritis there are neuralgic paroxysms along the entire course of the nerve, with periods of apparently complete remission, but during which a continuous pain persists at the level of the inflamed point.

Muscular hyperæsthesia has been given by Weir Mitchell as a sign of neuritis, even in the absence of cutaneous hyperæsthesia. At a later period, the loss of tactile sensibility is observed; this anæsthesia is due to the destruction of the nerve fibres below the diseased point, but the spontaneous pains persist, for the irritation which exists above the diseased point continues to be transmitted to the brain. There is then a painful anæsthesia. Sometimes the anæsthesia shows itself early, in acute neuritis (Nothnagel), and over limited points of the territory of the nerve. These patches of circumscribed anæsthesia have been observed in herpes zoster by Charcot, Rendu, and Damaschino. Hybord has observed anæsthesia in ophthalmic zona, and Rendu has studied it in anæsthetic leprosy.

(2) *Neuritis of Motor Nerves.*—The history of neuritis of the motor nerves is little known; its only characteristic symptom is paralysis, which, however, is not constant when the inflammation is slight, or when there is only a perineuritis. It is generally preceded by tremblings, muscular shocks, convulsions, and contractions; but these phenomena may exist without there being any signs of nerve inflammation.

What is the pathogenesis of these contractions? Do they result from direct, centrifugal irritation of affected motor filaments, or are they of a reflex nature? Nothnagel, while recognizing the frequency of contractions in neuritis, does not venture to decide upon their symptomatic value, nor upon their mode of origin.

When degeneration of the nerve supervenes, paralysis occurs; it is quite rapidly developed, and is characterized by the abolition of voluntary and reflex movements, and by the loss of electric contractility.

Motor disturbances may be the consequence of an interstitial, or of a parenchymatous neuritis; the latter especially gives rise to grave and obstinate palsies, while slight paresis is the result of perineuritis.

There is one important symptom of neuritis: muscular atrophy, or dystrophia, which is sometimes precocious. Landouzy has made a complete study of it as regards the sciatic nerve, and he has made it a diagnostic sign

[1] Sometimes the pain is excessive, and in nervous persons is accompanied with agitation, convulsions, and delirium.

between neuritis and neuralgia. But from the absence of atrophy, the integrity of the nerve cannot be necessarily inferred. This atrophy is attributed to the suppression of the trophic influence exercised by the spinal cord upon the nerves and muscles.

Electrical exploration gives results which are often uncertain. In the early stage of acute neuritis, the electric contractility is often increased; it is null where the nerve fibres have undergone degeneration, and when there are paralysis and muscular atrophy, but if the degeneration is incomplete, the contractility is preserved. Generally, the gravity of the paralysis is in relation to the diminution of the electric contractility, so that electrical exploration may be useful for prognosis.

(3) *Neuritis of Mixed Nerves.*—The symptoms of neuritis of the sensory and of the motor nerves, may be combined when a mixed nerve is affected. But it must be remarked, that generally in inflammation of a mixed nerve, the disturbances of sensibility predominate, at least at the beginning. It is also to be remembered, that the symptoms which are observed, rarely remain limited to the territory of the inflamed nerve. Aside of the phenomena which may be directly referred to inflammation of a nerve, it is convenient to place those which are due to extension of the neuritis towards the spinal cord—to reflex excitation, which it is that causes convulsions and contractions; thus, a kind of writer's cramp has been seen to result from a neuritis of the radial nerve (Meyer); and general convulsions of various forms have been attributed to an analogous process.

Neuritis may be followed by the development of numerous *trophic disturbances;* but they are identical with those which we have already described as resulting from wounds of nerves; whether the neuritis is spontaneous or traumatic, the cutaneous, muscular, articular, and other alterations present the same characters, and depend upon the same pathological process.

Among the trophic disturbances, those must be distinguished which are due to nerve irritation (vesicles, herpes zoster, pemphigoid and eczematous eruptions, ulcerations, etc.), and those which are due to want of action, to nerve atrophy (glossy skin, ulcerations, alterations of the hair, nails, etc.).

*Diagnosis of Neuritis.*—The diagnosis of neuritis is often difficult, but nevertheless acute neuritis may be recognized, if there are observed spontaneous pain, sharp and continuous, pain provoked by pressure over a long portion of the course of the nerve, palsies, and precocious muscular atrophy. When there is a subacute or chronic neuritis, it is liable to be confounded with neuralgia, and all the more because the boundary between the two affections is not well marked; for the means of distinguishing them, the reader is referred to the section on neuralgia. Neuritis may be distinguished from muscular rheumatism by the fact that, in the latter, pressure upon the muscles is painful throughout their whole extent.

*Prognosis.*—The prognosis of neuritis should be always guarded, both on account of the duration of the disease, which may be long, and on account of the palsies and muscular atrophies which are its consequence, and which are persistent and difficult to cure. It must be added that the lesion may extend towards the nerve centres. According to Lereboullet, traumatic neuritis is, in this respect, less grave and less lasting than spontaneous or rheumatic neuritis.

*Treatment of Neuritis.*—Many of the indications which were given in considering the treatment of wounds of nerves, are applicable to neuritis in general. In acute neuritis, absolute rest of the limb should be directed, with

the use of antiphlogistics, leeches—though at times their bites are very painful—subcutaneous injections of morphia, and purgatives. In chronic neuritis, which often resists treatment, besides rest of the limb, revulsives should be employed—blisters, applications of iodine, or the hot iron—with the use of diaphoretics, hydrotherapeutic measures—ice, cold baths, douches, vapor baths, turpentine baths, etc.—antispasmodics, narcotics, and finally the continued current. It is of the highest importance that the general state of the patient should be inquired into, and, if he is arthritic,[1] as is frequently the case, that he should be given appropriate remedies in full doses.

## Neuralgia in General.

The tendency to multiply operations upon nerves, particularly in neuralgias, requires the surgeon to have an exact knowledge of their symptoms and pathogeny, so that he may be able to determine the indications for operative intervention.

Neuralgia is a clinical syndrome, which belongs, indeed, to different morbid states of the nerves, of which some are not accompanied by any appreciable alteration, and of which others present various changes, too slightly marked for it to be possible to recognize them in the patient, or to classify them in other divisions of nerve pathology. Since the functional disturbances are the same, with the exception of some slight variations, in these different states, surgeons still join them together under the name of neuralgia, while at the same time endeavoring to discover all the signs which may permit their anatomical diagnosis to be established. This group is accordingly becoming smaller, with the progress of pathological anatomy and clinical analysis.

We admit then three principal varieties of neuralgia, the symptomatic, the reflex, and the idiopathic. There is here no question except of the neuralgias of the nerves of animal function.

Every pain is not a neuralgia. This is a sharp pain, spontaneous, occurring in paroxysms, remitting, and situated over the course of the nerves.

*Etiology of Neuralgia.*—The causes of neuralgias may be divided into predisposing causes, general causes (the diathetic and dyscrasic causes of Huchard), and determining causes.

(1) *Predisposing Causes.*—Neuralgias are exceptional during infancy, frequent from twenty to sixty years of age, and rare beyond this time of life. The female sex seems to furnish a predisposition, and heredity also plays a certain part, by giving to the descendants a constitution favorable to the development of neuralgia. Persons of a lymphatic, and those of a nervous temperament, are predisposed. Certain physiological states, such as menstruation and pregnancy, also predispose to neuralgias. Occupations which expose to sudden changes of heat and cold, damp and badly situated dwellings, and certain states of the atmosphere, are again predisposing causes. According to Weir Mitchell, the pains are rather connected with the lowering of the atmospheric pressure (in storms, for example), than with changes of temperature, but moisture of the atmosphere continues to be the most effective cause; the influence of atmospheric electricity is yet to be investigated.

(2) *General causes* may give rise to neuralgias which are described by Huchard under the name of diathetic, dyscrasic, and toxic neuralgias; these

[1] [See Vol. I. p. 311.]

appear to depend upon an alteration of the blood. "The blood, that regulator of the nerves, is deprived," he says, "of a certain number of globules; it reacts upon the nerves, and determines an exaltation of their properties."

These general causes are met with in anæmia, in chlorosis, in hysteria, in pregnancy, in lactation, in convalescence, in cachexias, such as syphilis and malaria, in poisoning by lead and by mercury, in Bright's disease, in diabetes, in influenza, in catarrhal fever, in measles, etc., and often in arthritism[1]—rheumatism and gout.

(3) *Determining causes* are divided into peripheral causes, which act upon the nerves; central causes, which act upon the nerve centres; and causes which act at a distance, or by reflex action.

The *peripheral causes* include all the causes of traumatism of the nerves themselves, which we have already studied, and which give rise to *traumatic neuralgia*, which may often be attributed to a congestion, or to an inflammation of the nerves. They include also foreign bodies in the nerves, and diseases and tumors of these structures; the imprisonment of a nerve in a mass of callus, its compression by cicatricial tissue or by eburnation of bone-structure—neuralgic osteitis (Gosselin), neuralgia of edentulous persons (Gross).

To these must be added the alterations of the nerve brought about by lesions of the neighboring parts; and, finally, cold, which often plays an important part in the development of certain neuralgias, particularly among arthritic subjects (rheumatic, neuralgic).

The *central causes* include the lesions of the nerve-centres or of their membranes (tumors, etc.).

*Reflex neuralgias* are brought about by disease of a more or less distant organ. On this subject Huchard says, as follows: "In consequence of a sympathy existing between deep-seated organs and the parietes which cover them, very varied internal affections, painful or not, cause in the nerves of the walls the same morbid impressions which the visceral ramifications have undergone." To this class of neuralgias belong the lumbo-abdominal and other neuralgias which are seen in affections of the uterus or ovaries, in orchi-epididymitis (Mauriac), etc. There might perhaps be included here, some of the *precocious*, *secondary*, *traumatic neuralgias* of Verneuil, which manifest themselves at the beginning of the reparatory process, and which will be again referred to. They are to be distinguished from *primary*, *traumatic neuralgias*, resulting from nerve-wounds, and from *tardy*, *secondary*, *traumatic neuralgias*, which occur after the work of cicatrization is completed, as, for example, in stumps.

*Symptoms of Neuralgia.*—The essential, and often the only, symptom of neuralgia is *pain;* and a distinction must be made between *spontaneous* pain and the pain caused *by pressure;* the former often presents itself under two forms; a continuous pain, and a remittent pain.

*Continuous pain* manifests itself by a sensation of tension, of pressure, and of aching; it affects by preference certain special foci, which then form the points of departure of the remittent pains.

*Remittent pain* sometimes presents a regular periodicity (intermittent pain); it is acute, and shows itself under the form of paroxysmal pain, throbbings, tearings, prickings, burnings, electric shocks, and painful jerks. It shows itself in paroxysms, during which the pains recur several times in a minute, or only once, twice, or three times in a quarter of an hour, etc. The whole duration of the paroxysm is extremely variable—a few minutes, some hours,

[1] [See Vol. I. p. 311.]

or several days, etc. When these pains come very close together, the patients feel disturbed, and there is a more or less intense anxiety, with insomnia, while the general state may end by being changed and presenting a kind of acquired nervousness. Sometimes the pains diminish, or even disappear, when the patient is engaged in important or forced occupations. These remittent pains have foci where they remain fixed during the same paroxysm, or during a part of its duration; at other times they are accompanied by painful irradiations. In other cases the foci change their seat, and move either towards the roots of the nerves (ascending neuralgia of Cotugno), or, more frequently, towards their extremities. In a word, the change of place of the foci does not follow the law which directs the propagation of the peripheral impressions; it does not generally follow the direction of the nervous influence; though we know, it is true, from the experiments of Bert, that the sensory nerves are capable of transmitting impressions in both directions. It has been said, following Valleix, that these foci are precisely the seats of pain (*points douloureux*) which are revealed by pressure; but although this may be true for a great number of cases, it is not always so.

In regard to the location of the darting pains, this varies; sometimes the darting is felt in the affected part; sometimes it takes the form of flashes (lightning pains), which follow the course of a nerve branch; sometimes there are several painful irradiations starting from the same point.

*Pain upon Pressure.*—Pressure exerted by a large surface, such as the palm of the hand, generally allays the pain; by pressing with the point of the finger, on the other hand, there is brought out along the course of the nerve, at one or several points, a pain which is at times very sharp; if the pressure is repeated, however, only a very slight pain is ultimately caused. Pressure exasperates the continuous pain, and occasionally determines an explosion of the darting pains.

According to Valleix, the *points douloureux* are at the points of emergence of the nerve-trunks; at the points where they become superficial; at the points where the nerve-filaments traverse the muscles or the aponeuroses; and at the points where the nerve-branches are finally distributed to the integument. The same author thought that the pain of neuralgia affected exclusively the subcutaneous nerves, or those of tactile sensibility; but pressure over the deep nerves is often painful.

The points painful to pressure (*points douloureux*) are frequently absent. Trousseau proposed to substitute for them *spinous points* (*points apophysaires*),[1] but they have nothing characteristic in neuralgia, not even in intercostal neuralgia, where they may be wanting.

The number of painful points over the course of a nerve varies in each case. They may be one or two centimetres [half or three-quarters of an inch] in diameter; sometimes their boundaries are very distinctly circumscribed, at other times more diffused. The intensity of the pain on pressure is, generally, in relation to that of the spontaneous pain. Not only pressure, but efforts and movements of the patient, and the contact of hot or cold bodies, bring back the darting pains.

*Concomitant Symptoms.*—During the paroxysms, there may be observed, injection of the affected parts, congestion, increase of the secretions (mucus, tears, sweat, etc.), cutaneous hyperæsthesia or anæsthesia, and convulsive movements (*tic douloureux*); if any paralysis appears, it is because there is a grave lesion of the nerve.

Besides these local disturbances, there may be experienced general sensa-

[1] [The *spinous points* of Trousseau are situated over the spinous processes of the vertebræ, corresponding to the point of exit of the nerve from the intervertebral foramen.]

tions of irritation, anxiety, vertigo, and unfitness for work; at the end of the attacks, the patient sometimes passes a large quantity of watery urine.

When the neuralgia is chronic, trophic disturbances may appear; there have been noted, a hypertrophy of half the face (Axenfeld), falling of the hair, and, in recent times, increase of the subcutaneous fat and muscular atrophy; but then there is neuritis or a spinal lesion (Landouzy, Fernet).

Finally, the general health of the patients may be altered, they become impressionable and melancholy, and their digestive functions are impaired.

These symptoms of neuralgia may be met with in all the etiological varieties, but the *precocious*, *secondary*, *traumatic neuralgias* of Verneuil present certain peculiarities.

These show themselves generally, according to this author, apart from all material lesion of the nerves, after the cessation of the primary pain caused by the injury and the nerve lesion, and as early as the beginning of the reparative process in the wound, that is to say, during the first week; they differ from the tardy neuralgias which appear after cicatrization (*neuralgias of cicatrices and stumps*.

These neuralgias may be accompanied by clonic contractions, contractures, paresis, congestion, ecchymosis, and hemorrhage from the granulations; sometimes the wound assumes a diptheroidal aspect; finally, general phenomena, such as fever and vomiting, may be met with.

Verneuil distinguishes several varieties of this form of neuralgia, according to their seat: (1) Local pain, limited to the traumatic focus; (2) Local pain, with peripheral irradiations; (3) Local pain, with peripheral insensibility and distal manifestations; (4) Local, peripheral, and distal pain, all at the same time; and (5) Local insensibility, with pain only at a distance.

These neuralgias are intermittent, and are relieved by the sulphate of quinine.

The *course* of neuralgia is generally irregular. Its onset may be sudden, or it may be gradual, and preceded by a sensation of uneasiness. The attacks are of variable duration; they are remittent, and sometimes intermittent, as in malarial poisoning; the painful paroxysms, the darting pains which constitute them, occur with greater or less frequency, and are more or less violent.

The *duration* of neuralgia may be a few days, several months, or several years; the study of its causes accounts for all the variations here noted; neuralgia is then either evanescent or persistent.

The *termination* of neuralgia is never fatal, but it may change the general state of the patient, react upon his moral nature, and drive him to suicide. In some cases neuralgia disappears gradually, exhausting itself as it were; sometimes at the moment of its definitive disappearance, or upon the cessation of a paroxysm, there are observed so-called critical phenomena—cutaneous eruptions, diarrhœa, profuse diuresis, etc. Neuralgia generally disappears when an intercurrent disease supervenes. In other cases its disappearance is coincident with the occurrence of congestive metastases, or more often with the development of other neuralgias.

*Pathological Physiology.*—The pathological physiology of neuralgia is not yet completely known. What is the *cause of the pain;* in what does it consist? Is it a special excitation of the properties of the nerve, a particular weakening, or a modification of conductibility? We do not know. But it seems certain that there is no single lesion, nor one cause always alike, to explain the pain. Rigal admits a lesion of the nervous elements, or a disturbance in the molecular interchanges. Ouspenky, a partisan of the central theory of neuralgia, supposes that each pain is provoked, or at least accom-

panied, by the formation of products of the metamorphosis of the nervous system, and by their influence upon the latter.

What is the *seat of neuralgia?* "To what kind of lesion of the nervous system are" neuralgias "due," says Vulpian; "where are these lesions located? Are we concerned with a congestion, or with an inflammatory irritation of the affected nerve? Is it the nerve itself which is altered? Is it its peripheral extremity? Is it its central extremity? Is it the nerve-centre? While neuralgias," he adds, "have, according to various pathologists, their ordinary seat at the periphery of the nerves, or in a more or less extended portion of the nerve-trunk, I believe that, in a large number of cases, the alteration which causes these affections resides in the central extremities of the nerves; most frequently, perhaps, in the spinal cord or in its membranes."

Two theories, in fact, have been proposed on the subject of the localization of neuralgias:—

(1) The *central theory*, which is sustained by Vulpian, who would place the lesions of neuralgia in the spinal cord, or in its membranes; and by Anstie, who admits in every neuralgia a lesion of the sensory roots of the nerves in their intra-spinal course, and of their gray nuclei, etc.; and

(2) The *peripheral theory*, sustained by Axennfeld and Huchard, according to which neuralgias have their seat in certain only of the sensory fibres which compose the nerve-branches, and occupy the entire length or some isolated points of their course. In a great number of cases the seat of the pain is real and not virtual; that is to say, the pain is produced in the very places where the patients feel it, and is not simply felt as if it were produced there.

But, nevertheless, the spinal cord plays a part in the production and generalization of neuralgic pains, and in the development of peripheral, painful irradiations. The lesions, from being peripheral at the beginning, may become central, as we have already seen in regard to neuritis. The painful excitations originating from the periphery and from the diseased nerves, reach the spinal cells—sensory nuclei of Clarke's columns (Pierret)—and by their intervention determine these multiple irradiations. Finally, the spinal cord intervenes directly in trophic disturbances and in vaso-motor palsies.

The discovery of the *recurrent fibres* has thrown a new light upon this subject. It explains why the influence of the sensory nerves extends beyond their anatomical zone of distribution; any particular region may be connected with others by several nerve-trunks or branches, owing precisely to the existence of these fibres ascending in the course of neighboring trunks. It was thus that, in one case, Tripier relieved a neuralgia of the ulnar nerve by compressing the musculo-cutaneous. This also accounts for the failure of certain neurotomies.

Finally, Cartaz explains by the recurrent fibres, both the existence of the *points douloureux* and the seat of neuralgias. Indeed, according to the investigations of Arloing and Tripier, the recurrent fibres on the face, for example, stop below the bony foramina, to expend themselves in the neighboring tissues. Now, these points, provided with a rich nervous network, correspond precisely with the *points douloureux* of Valleix. According to Cartaz, certain so-called functional neuralgias are caused by *peripheral neuritis* of the nerve-trunks, filaments, or terminal networks.

In conclusion, the three following propositions, established by Huchard, may be admitted:—

(1) Certain neuralgias are primarily peripheral in their seat, and remain always peripheral during their whole evolution.

(2) Others may be primarily peripheral, and become central secondarily.

(3) Others, finally, are primarily central.

*Diagnosis of Neuralgia.*—The diagnosis of neuralgias presents great difficulties, as regards their cause and intimate nature; I shall try to state the matter as exactly as possible. Let us first recall the characteristic signs of neuralgia.

Neuralgia is characterized by a spontaneous, remittent pain, often grafted upon a dull, continued pain. It is seated along the course of the nerves, and radiates generally from the centre towards the periphery. The pain frequently reappears upon pressure at certain ascertained points, and is accompanied by certain functional disturbances.

(1) It is first necessary to diagnosticate neuralgic pains from *other pains of central or peripheral origin.*

*Myosalgia* or *myalgia* occupies, not the course of the nerves, but that of the muscles; it is excited by each contraction of the affected muscle, and presents neither irradiations nor paroxysms.

The *osteocopic pains of syphilis* are generally symmetrical.

The *pains of chronic poisoning by alcohol or by mercury* are most frequently continuous, and limited to the peri-articular structures of the extremities.

But it is especially in regard to the pains of *posterior myelitis* and of *locomotor ataxia* that the diagnosis should be exact. These pains are not seated over the course of the nerve-trunks or branches, and are not increased by pressure. They consist in a series of dartings which occur in a circumscribed region, and sometimes traverse from above downwards the whole extent of the limb. They are comparable to the sensation produced by the electric spark (*lightning pains*); at other times they are more persistent, and give the sensation of a gimlet (*boring pains*) in the bones or articulations.

*Spinal irritation* presents *spinous points* (*points apophysaires*) which are characteristic of cutaneous hyperæsthesia, with visceral congestions and paretic disorders of the lower extremities.

Neuralgia sometimes occurs *in an epileptic*, and then becomes the occasion of attacks of diverse nature. These phenomena must be carefully investigated by a minute examination of the patient. In a case of neuralgia of the inferior dental nerve in a male adult, subject to attacks of coma, death occurred suddenly a few hours after resection of the nerve. The patient's physicians had advised against any operation, fearing the occurrence of some accident, but had finally yielded to his reiterated requests.

(2) The neuralgia being recognized, it is necessary to seek to *ascertain its cause*, peripheral or central.

There may be *congestion of the nerve*, *or of its centre of origin.* Gubler considers malarial and rheumatic neuralgias to be due to congestion.

In *neuritis*, the pain is continuous, and is increased by pressure over a long extent of the course of the nerve. Paroxysms occur, especially upon movement, or upon external excitation; cutaneous hyperæsthesia occurs more frequently; anæsthesia is earlier developed. Rapid muscular atrophy supervenes, with deposit of subcutaneous fat and persistent trophic disturbances, those of neuralgia being especially functional disturbances. Finally, neuritis has a cyclical evolution. To neuritis belong most of the traumatic neuralgias and many of the arthritic and rheumatic neuralgias.

*Compression* of nerves by tumors, by indurated tissue, by cicatrices, or by callus, may cause neuralgias which run a chronic course, are continuous, are accompanied by trophic disturbances, and present, in a word, the symptoms of what Hallopeau has called "névralgies-névrites." Neuromata and so-called "irritable" tumors are also accompanied by neuralgia (neuralgia of stumps).

What is the *exact seat of neuralgia?* Must we admit the existence of a lesion of the nerve-trunk and its terminal branches, or of its sources of origin in

the spinal cord? The surgeon should inquire whether the neuralgia has not as its point of origin a lesion situated outside of the nerve, in its neighborhood, or in a distant organ (reflex neuralgia).

Is there, finally, simply an *essential neuralgia*—a painful neurosis of the sensory nerves? (Hallopeau.) In these cases, the beginning is sudden, there is no continuous pain, nor pain on pressure; the dartings are of extreme severity and of short duration.

(3) Finally, it will be necessary to endeavor to recognize the *nature of the neuralgia*—the nature of the lesion which determines its production. Is the patient arthritic, rheumatic, or gouty? Is there a complication of chloranæmia, malaria, syphilis, or certain chronic poisonings, etc.? By such inquiries it can be ascertained whether the neuralgia is or is not dependent upon a general, constitutional condition.

*Prognosis of Neuralgia.*—The prognosis varies with the variety of the neuralgia and with its cause. It is gravest in neuralgias of central origin, and where there are positive nerve-lesions; the neuralgia may under such circumstances be persistent and even incurable. Neuralgias from congestion are less serious, though occasionally they are very persistent; all neuralgias are of this character in old, feeble, and neuropathic individuals.

Neuralgias are subject to frequent relapses, especially when they are dependent upon constitutional conditions. Syphilitic and malarial neuralgias are the most amenable to treatment.

*Treatment.*—Three indications are to be fulfilled: (1) To combat the general constitutional state; (2) To combat the local nerve lesion; and (3) To combat the pain.

(1) *General Medication.*—This addresses itself to the nature of the neuralgia, which is often, as we have seen, dependent upon a general, constitutional condition. This condition must be modified, if it is wished to obtain the disappearance of the neuralgic attack, and to prevent the recurrence of new attacks. General medication has often succeeded when all other measures have failed. Moreover, when it is indicated, care should be taken to employ it at the very beginning of the treatment. The medication varies according to the nature of the constitutional state, according as there is arthritism, malaria, syphilis, etc.

In addition to this general medication, some general rules of hygiene must be enforced: a non-exciting diet; abstinence from coffee, tea, and alcohol; mental repose; avoidance of sexual relations; exercise in the open air; hydrotherapeutic measures—anodyne baths, cold baths, sea baths, etc.

The form of hydrotherapy to be employed, and the nature of the baths, will vary according to the general conditions; warm and cold douches, transition douches, vapor baths, fumigations, hot-air baths, Moorish baths, etc.

(2) At the same time that general remedies are administered, it is necessary to *control the local nerve-changes.* Surgical interference is necessary at the very beginning if there is a mechanical cause, such as the presence of a foreign body, or compression and irritation of the nerve by an exostosis, by callus (in which case the inclosed nerve must be released), by a cicatrix, or by a tumor of the nerve or of its neighborhood.

If congestion, or if neuritis, exists by itself, or persists, cut-cups may be employed, revulsives over the course of the nerve, blisters, irritant applications, the hot iron, cauterizations with sulphuric acid (which, however, must be used cautiously), local douches, filiform douches, etc. Aquapuncture has been recommended (Siredey), as have irritant hypodermic injections—injec-

tions of nitrate of silver or of sea-salt (Luton); electricity may be usefully employed.

(3) To the two forms of medication already described there must be added that which has for its end the *combating of pain*. This variety of medication always plays an important part, and sometimes is employed alone when there are found neither morbid constitutional states nor local nerve-changes. There is generally too great a tendency to rely upon this form of treatment, while the others are more or less completely neglected. It renders good service, but the former only are truly curative.

To relieve the pain of neuralgia, anodynes may be employed by hypodermic injection, as topical applications, and by internal administration. The hypodermic injections most often employed are those of muriate of morphia, from five milligrammes ($\frac{1}{12}$ grain) upward; of chloroform (Bartholow, Besnier) in doses of from one to three grammes (15 to 45 minims); and of atropia, in doses of from one to two milligrammes ($\frac{1}{60}$ to $\frac{1}{30}$ grain). The latter remedy is somewhat dangerous. Morphia has also been administered by the endermic method, by means of a small blister. Different topical remedies have been applied, some with opium for a basis, such as liniments containing laudanum; applications to the skin of chloroform and ether have also been employed, as have anodyne ointments, ointments of veratria and of morphia, etc. Finally, anodynes are administered internally: opium, laudanum, chloral, aconitia, bromide of potassium. The sulphate of quinine is very efficacious in the secondary traumatic neuralgias (Verneuil). Inhalations of chloroform and ether are also employed; but they have frequently been the cause of accidents.

Armaingaud has obtained successful results by the employment of revulsives, blisters, the hot iron, etc., over the position of the painful spinous points. Huchard attacks these with the ether spray applied over the vertebral column.

Finally, if all medication fails, *surgical intervention* becomes necessary. An energetic compression over the course of the painful nerve has sometimes been of service. But recourse has been especially had to section or resection of the nerve, and to elongation, with or without crushing. These operations will be studied hereafter. In recent times the boldness of operators has extended to tearing out the branches of the trifacial, a heroic operation which might prove dangerous by irritating the ganglion of Gasser, or the central origins of the nerves.

## Tumors of Nerves.

Odier, of Geneva, in 1803, described under the name of *neuromata*, all tumors developed in the course of the nerves, whatever was their structure. In 1822, Aronssohn, following Camper and Alexander, endeavored to divide them into two principal classes, according to whether the tumor grew from the medullary structure of the nerves, or from their interstices and from their neurilemma; but his attempt remained without effect, the more so that in 1825 appeared the work of Descot, who considered all neuromata as being of a cancerous nature, an opinion which was adopted by a great number of surgeons.

In 1853, Houel, recording a case of multiple neuromata, admitted two principal varieties: fibrous tumors and fibro-plastic tumors; but Lebert, in the report he made in regard to Houel's work, considered neuromata to be all formed by fibrous tumors.

In Germany, Fuhrer and Virchow found that certain neuromata contained

nerve-fibres, and in 1865 Foerster recognized two varieties of tumor of nerve-tissue—one formed by a substance analogous to the gray substance of the brain (medullary neuroma), the other constituted by nerve-fibres (fasciculated neuroma). This view was sustained by Virchow in his "Treatise on Tumors."

At the present time, notwithstanding the progress of pathological anatomy, it is not yet possible to give an exact classification of the tumors of which the nerves may be the seat; the attempt may be made, however, to frame a kind of outline which will serve to classify published cases; but it must not be forgotten that a certain number of these are still the subject of discussion, so that their actual nomenclature is not definitively settled. To the difficulty of making an anatomical diagnosis, not only at the bedside of the patient, but even by naked-eye and microscopical examination, must be attributed the want of precision which science presents upon this question.

In the following pages, tumors of nerves will be described as being of three principal varieties: (1) those which are formed by the nerve-tissue itself; (2) those which are formed from the connective tissue of the nerves; and (3) the cancerous degenerations of nerves.

In accordance with the principles of classification of tumors adopted in general pathology, I shall reserve the name *neuromata* for tumors which are constituted of nerve-tissue of new formation; the other tumors of nerves will be designated, as is done with tumors of other organs or tissues, by the name of the predominant tissue in the tumor. In connection with this subject, we may recall the words of Cornil and Ranvier, "that for a tumor to merit the name of neuroma, it does not suffice that it contains nerve-fibres; it is further necessary that the number of these latter allows it to be supposed that it is a new formation of nerve-elements."

In regard to the *painful subcutaneous tubercle*, I shall describe it separately; if sometimes it has been found constituted of nerve-fibres (L. Labbé, Legros), more often it has been exclusively fibrous; moreover, it is not situated in the course of a nerve-trunk or of an important branch, and in reality it constitutes, as we shall see presently, a quite distinct clinical variety.

It is only the anatomy of the several forms of nerve-tumor that demands a separate description for each; of the other parts of their history a collective study will suffice, the peculiarities of each variety being indicated when necessary; in this second part of the investigation, the term *neuroma* will often be employed as synonymous simply with nerve-tumor.

Anatomy of Nerve-Tumors.—Tumors of nerves, as has been already said, are divided into three principal varieties: (1) Tumors formed by the nerve-tissue (*neuromata*); (2) Tumors formed from the connective tissue (*fibromata*, *sarcomata*, *myxomata*, *cysts*); and (3) Cancerous and epithelial degenerations.

I. Neuromata.—The tumors constituted of nerve-tissue of new formation are divided by German authors into two varieties, viz.: (1) *Medullary* or *cellular neuromata*, consisting of ganglionic cells, and (2) *Fasciculated* or *fibrillar neuromata*, formed of nerve-fibres. A third group may be added, viz.: (3) that of the *plexiform neuromata*.

(1) *Cellular neuromata*.—These are met with in the nerve-centres, and sometimes in encephaloceles; in one case, a tumor of this kind was found in a nerve-ganglion. According to Virchow, there may be a formation of nerve-substance in encephaloceles, and in congenital tumors of the sacrum and coccyx; as to the formation of normal ganglia upon the course of nerves, it is far from being established. Possibly a hyperplasia of undescribed, though pre-existing, ganglia may be admitted. Indeed, the existence of these neuro-

mata upon the peripheral nerves is not demonstrated, and it is now long since that the opinion of Serres has been abandoned, which considered the multiple tumors of nerves as ganglia of new formation, and described the affeetion under the name of *neuroplasia*.

It may be said, however, that Foerster admitted their existence, and that Robin has found, in a ease of alteration of the solar plexus, a new formation of nerve-eells.

(2) *Fibrillar neuromata.*—These are constituted of nerve-fibres of new formation, and are divided into two kinds, which may be eonsidered as two stages of the same affection; the *myelinic neuromata*, formed by fibres with myelin, and the *amyelinic neuromata*, formed by fibres without myelin. The existence of these latter neuromata is contested by several authors, on aceount of the difficulty of distinguishing the fibres of Remak. Billroth says that under this name have been described fibromata, which constitute certain varieties of multiple nerve-tumors. We should then be as yet reserved upon the subject of the existence of amyelinic neuromata (Cornil and Ranvier).

The *myelinic fibrillar neuromata* have, for their type, the *neuromata of stumps after amputation.* Apart from these cases, they are rare, though this is not the opinion of Foerster and Virchow, who place in this variety most of the fibromata of nerves, which growths they resemble when seetions are examined with the naked eye.

These tumors are further deseribed under the name of *traumatic neuromata*, for they are observed, not only in stumps after amputation, but after wounds of nerves, ligations of nerves, and even, according to Tripier, as a result of subcutaneous nerve-lesion (Weissmann, Dehler); they thus constitute certain painful subcutaneous tubercles (L. Labbé, Legros), and also plexiform neuromata (Verneuil).

The type of these tumors is the *amputation-neuroma.* It has its seat upon the extremity of the divided nerve, at a greater or less distance from the cicatrix, according as the nerve has retracted, or has been cut at a higher or lower point. Its shape is oval, and often flattened, and it is continuous, directly or by means of radicles, with the cicatrix.

The size of these neuromata varies from that of a large pea to that of a hen's egg (Hutin); they are grayish, more or less vascular, firm, and elastic, and they present, upon section, the characters of compact fibromata. With the microscope, it is seen that they consist of interlacing and twisted nerve-fasciculi, inclosing myelinie nerve-fibres. Between them is found a variable amount of eonnective tissue. Sometimes the nerve-tissue predominates, sometimes the connective tissue. Foerster seems to believe that these nerve-fibres are not continuous with those of the nerve, and that they constitute a separate system of fibres, originating from the connective tissue. Cornil and Ranvier think that the twisted fibres have their origin from the old fibres, and are continuous with them.

Their mode of development may be understood by referring to the phenomena of regeneration of nerves. Cornil and Ranvier express themselves upon this subject, as follows:—

"In the end of the central segment, two or three days after the operation on the rabbit, the axis cylinders become hypertrophied in the neighborhood of the section, they seem then to be composed of fibrils (elementary fibrils), but subsequently they divide in the direction of their length, budding and extending into the cicatricial band. These nerve-fibres, then without medullary matter, which result from the budding of the old axis-cylinders, divide and subdivide in such a manner that a single nerve-fibre may give origin to a more or less considerable number of new nerve-fibres. Afterwards these

**nerve-fibres become covered with a medullary sheath, and assume all the characters of myelinic nerve-fibres."**

From what has been said, it can be seen that, without denying the genesis *in loco* of the nerve-fibres (Virchow), several authors admit that most often they trace their origin from the budding of the axis-cylinders; this also accounts for the change of amyelinic into myelinic fibres.

Several neuromata may be united so as to form a globular mass, or the different neuromata of a stump may be joined by loops (Larrey). Virchow admits that tumors of the same nature may be developed along the course of the nerves in the neighborhood of other chronic changes.

Reuillet has published the case of a man thirty-five years old, who at the age of six years had a fracture of the right humerus with a wound; at the autopsy there were found an increase in size of the cervico-dorsal nerves, which presented tumors along their course, and an increase in size of the ganglions of the roots of the nerves, and of the spinal cord in the cervico-dorsal region. There were secondary lesions of the articulations and of the muscles. These changes in the nervous system were attributed to an irritation of the peripheral nerves, which had caused hypertrophy and hyperplasia of the nerve-fasciculi. Tripier has pointed out that in this case the tumors were formed by medullary fibres due to a multiplication of the axis-cylinders.

(3) *Plexiform Neuroma.*—Under the name of *plexiform neuroma*, or *cylindrical neuroma*, Verneuil described, in 1861, a variety of congenital tumor which he had observed for the first time in 1857, with Depaul; the case was one of tumor of the nucha, with hypertrophy of the skin, which formed a large fold. The mass of the tumor described by Verneuil, was formed of elongated nerves, twined around like a bunch of varicose veins, and presenting anastomoses, with enlargements analogous to neuromata. These hypertrophied cutaneous nerves made up two-thirds of the mass of the tumor (*cirsoid neuromata* of Burns and Rizzoli). Among the nerve-trunks, some were formed of one, two, or three nerve-fibres, and of fibro-plastic tissue; others were almost exclusively composed of nerve-fibres, with a double or single contour.

In 1859, Guersant presented to the Society of Surgery a young girl, who had, in the mastoid region, a congenital tumor of the same nature, as was demonstrated by the anatomical examination made by Verneuil. Alongside of these cases should be placed those of tumor of the skin described by Valentine Mott (1854) under the name of *pachydermatocele*, and those which Gayet has reported under the name of *general connective-tissue hypertrophy*. Billroth, in 1869, published a case of plexiform neuro-fibroma of the upper eyelid and of the temple.

Numerous cases have since been added to the above; but authors are not yet agreed as to their interpretation. Virchow joins in one and the same category the cases of Verneuil and those of Valentine Mott, and refers them to *congenital elephantiasis*. He considers as cases of *acquired elephantiasis*, a case of Verneuil's, of plexiform neuroma of the prepuce, and two cases of Chelius and of Barkow, in which, following an injury, there supervened a swelling of the inferior extremity with chaplet-like hypertrophy of the tibial nerve. This form of nerve-hypertrophy might perhaps be compared with the case of Reuillet and Tripier, cited above in connection with neuromata properly so called.

Cartaz, in 1876, gave a description of plexiform neuroma based upon thirteen cases. The tumor presents itself in the form of a diffuse, flabby swelling, in the midst of which are felt cords which glide from under the finger;

the skin is thickened. The tumor is constituted of hypertrophied, tortuous nerve-trunks, bound together by connective tissue. The connective-tissue hypertrophy surrounds the nervous element, and may cause it to disappear; this form of tumor may thus gradually become assimilated to a fibroma.

In a case of plexiform neuroma recorded by Winiwarter, there were at the same time a development of diffuse fibromata in the nerves, with formation of new nerve-fibres, and, in a part of the tumor, the formation of a sarcoma at the expense of the nerve-trunks.

R. Marchand, in 1878, in a *Memoir upon the Plexiform Neuroma*, said that this name might be replaced by that of *cylindrical fibroma of the nerve-sheaths.* According to this author there is no multiplication of nerve-fibres, which, on the contrary, undergo atrophy or disappear.

Finally, quite recently (1882), in the Society of Surgery of Paris, after the presentation by M. L. Labbé, of a patient who was considered to have an elephantiasis of the face, a discussion arose as to the nature of the tumor. Verneuil regarded it as a plexiform neuroma; Trélat, as a degenerated, congenital erectile tumor; Desprès, relying upon the observations of Ollard, considered it a soft elephantiasis; Guéniot recalled the fact that he had presented, under the name of "hypertrophie nævus," a tumor which had the same appearance, and which had been found to be constituted of the elements of the skin and of the cellulo-adipose tissue.

As will be seen, it is difficult to decide definitively the place in nosology which should be occupied by the variety of tumor described under the name of plexiform neuroma.

The alteration of the skin had led some authors to consider the neuroma as a primary lesion of the integument, extending secondarily to the nerves of the region; but as Cartaz points out, the inverse hypothesis, that of a primary hypertrophy of the nerves and secondary implication of the neighboring tissues, may also be sustained. If anatomical examination has given different results in different cases, this is owing to the tumors having been examined at different periods of their development, the nerve-elements undergoing atrophy and disappearing in consequence of the growth of the connective tissue.

The position here assigned to the plexiform neuroma, between the true neuroma and the nerve-tumors originating in the connective tissue, seems then justifiable, at least for the present. The plexiform neuromata are quite often indolent, congenital tumors, of slow development; most surgeons who have observed them recognize the necessity of their removal, on account of their progressive development and of the possibility of their degeneration, as in Winiwarter's case.

From twenty-eight cases of plexiform neuroma collected by Poinsot, it is found that the frequency of the lesion continues to increase from birth to the age of twenty years; it then diminishes, and does not again increase until from forty to fifty years. These tumors are not the seat of any pain.

II. Tumors formed at the expense of the Connective Tissue of the Nerve.—Besides neuromata, there are found in the nerves several varieties of tumor which have their origin in the connective tissue; these are *fibromata*, *sarcomata*, and *myxomata;* Virchow has added *gliomata*, or sarcomata of the neuroglia, the connective tissue of the nerve-centres, and *telangiectasic neuromata*, in which the vessels of the tumor occupy a predominant place.

The frequence and variety of the connective-tissue tumors, are explained by the abundance and varied forms of this tissue met with in the nerves. The nerves are surrounded by the neurilemma, a connective-tissue sheath which isolates them at the same time that it unites them to the neighboring tissues,

and which moreover sends prolongations into the interior of the nerve-trunks between the different fasciculi of which they are constituted. Each fasciculus is itself surrounded by another sheath formed of delicate connective-tissue fibres (*perneurium* of Robin, *lamellar sheath* of Ranvier), which also sends prolongations into the interior of the fasciculus; finally, the nerve-fibres are surrounded upon all sides by thin connective-tissue fibres.

(1) *Fibromata of Nerves.*—The fibromata of nerves are more frequent than the sarcomata. Foerster and Virchow regard the cases published under this name as cases of neuromata with amyelinic fibres; Lebert grouped together under this name the majority of nerve-tumors. The fibromata are developed at the expense of the connective tissue of the nerve, from either the neurilemma, the perineurium, or the interfibrillar tissue, and even the sheath of Schwann and its nuclei may, according to Christol, contribute to the formation of the new fibrous tissue. It was upon this difference of origin that Lebert based his classification of neuromata into (1) interfibrillar, or central neuromata; (2) peripheral neuromata, and (3) mixed neuromata. As a result of inflammation of nerves, there are sometimes found upon their surface, small, circumscribed, fibrous tumors, which are only the traces of a *chronic perineuritis.*

Fibromata of nerves are often solitary, but they may also constitute the tumors of nerves which have been described under the name of *multiple neuromata.* Their size also is variable, and they may reach large dimensions.

The tumor may be of a composite character. Cystic fibromata have been met with (Smith, Houel, Trélat); Poinsot observed a tumor which included fibrous tissue, fibro-plastic elements, and cystic cavities. Fibromata are sometimes observed at the extremities of divided nerves, in the neuromata of amputations, which are generally considered as neuromata with amyelinic fibres. They constitute also a variety, or a stage, of the plexiform neuromata—cylindrical fibromata of the nerve-sheaths (R. Marchand).

The histology of these tumors is still incomplete, and I shall, therefore, give a summary of the results obtained by the examination of two varieties of fibroma.

Cornil examined a solitary fibro-myxoma of the sciatic nerve, removed by Trélat; in this case the fibrous element predominated, and the new tissue existed solely in the interior of the lamellar sheath; it formed a thick zone within this, and pushed away the nerve-fibres to the centre of the fasciculus. Each nerve-fibre was surrounded by a new production of connective-tissue fibrils; the sheath of Schwann presented a multiplication of its cellular elements. The medullary substance and the axis-cylinders were preserved intact. Motility and sensibility had been retained by this patient. The neurilemma took no part in the formation of the tumor. Cornil calls attention to the point of origin of this tumor in the intrafascicular connective tissue.

In the case of a patient whom I have still under observation, and in whom a great number of nerves present tumors, I removed two which had increased a little in size, and had become painful. Their histological examination was made by Variot, who found that these tumors were formed by the junction of small, distinct tumors, developed, as in the case of Trélat's patient, in the interior of the lamellar sheath, or of the perineurium, by the proliferation of the intrafascicular tissue. The nerve-fibres were driven back against the wall of the fasciculus, and had preserved their integrity.

(2) *Sarcomata of Nerves.*—Sarcomata of nerves are tolerably rare; their existence has been denied by Virchow, but it is established at the present day without contestation.

The size of these tumors varies, and they may attain large proportions; in a case of Marchand's, the tumor measured 16 centimetres ($6\frac{1}{4}$ inches) in diameter. Most frequently the tumor is solitary; in a patient of Winiwarter's, however, there were several similar tumors upon the branches of the brachial plexus, and the patient, moreover, succumbed to a generalization of sarcoma in the lungs. Sarcoma may present various changes, which, however, are those of sarcoma in general; granulo-adipose degeneration; formation of hemorrhagic foci; mucous infiltration (Muron).

The *fascicular sarcoma* is the most common variety (Marchand); next is the *fibro-sarcoma* (Sottas, Foucault, Lanelongue); the tumor may present one or several *cysts* (Marchand).

Sarcomata have been met with upon the branches of the brachial plexus (Winiwarter), upon the median nerve (Grohe, Volkmann, Lanelongue), upon the ulnar nerve (Verneuil, Demarquay, Foucault), upon the sciatic nerve (Verneuil, Marchand, Bouilly, Mathieu), and upon the posterior tibial nerve (Broca).

With the sarcomata should be joined the *gliomata* of Virchow, or *neuroglic sarcomata* of Cornil and Ranvier. The German author has observed this variety of tumor in the cranial nerves, and particularly in the auditory nerve, but not in the peripheral nerves, though he considers its existence in them as probable.

(3) *Myxomata of Nerves.*—According to Cornil and Ranvier, these are relatively quite frequent, and are presented under the form of transparent, gelatinous, usually lobulated tumors. They have been confounded with cysts (Wilms). They may present various modifications, constituting the *fibro-myxomata* (Dolbeau, Trélat), *cystic myxomata*, *lipomatous myxomata*, etc.

Myxomata have been seen upon the radial nerve (Wilms), upon the ulnar nerve (Lafargue), upon the posterior tibial nerve (Dolbeau), and upon the peroneal nerve (Virchow and Gutteridge).

(4) *Cysts of Nerves.*—We have seen that cystic cavities may be met with in fibromata and sarcomata, but cases of isolated cysts of nerves are rare; one was observed by Beauchêne, in 1810, a cyst of the ulnar nerve, and one by Bertrand, a cyst of the median nerve. Lockhart Clarke says that there is in the Museum of St. George's Hospital, London, a preparation of a cyst of the median nerve.

III. CANCER AND EPITHELIOMA OF NERVES.—The existence of primary cancer of the nerves, regarded as frequent by authors at the beginning of this century, is disputed at the present day, except in the case of the retina and in that of the optic nerve. Foerster, however, according to Cornil and Ranvier, has observed primary carcinomata of the nerves, which, being at first the size of lentiles, had caused by their development the complete destruction of the nerve.

Secondary cancer is met with quite often; it has been well studied by Cornil. The invasion of the nerve is effected in two ways: (1) By direct propagation, by continuity; and (2) By the formation of tumors more or less distant from the primary cancer. The tumors thus formed are small in size, and sometimes multiple; the lesions affect the neurilemma, the perineurium, and the nerve-fibres, which may be destroyed.

Cornil has especially studied secondary cancer of the nerves following cancer of the neck of the uterus and cancer of the breast, particularly of the scirrhous form; he has also observed it as a sequel of cancer of the retro-

peritoneal glands. He has found cancerous tumors in the femoral, the sciatic, and the intercostal nerves, and in those of the brachial plexus.

Multiple Neuromata.—There may occur upon the nerves multiple tumors of variable structure and benign nature, which are designated by the name of multiple neuromata.

The distribution of multiple neuromata varies in different cases. Lebert recognizes, in regard to this point, three varieties: (1) tumors developing themselves upon several points of the same nerve, which assumes the appearance of a chaplet, or upon several of its branches; (2) tumors seen upon the nerves of one and the same region; and (3) tumors observed upon the nerves of very different regions, or neuromata of general multiplicity. Lebert unites the first two varieties under the name of neuromata of local multiplicity.

I. Neuromata of Local Multiplicity.—(1) *Multiple Neuromata of a Single Nerve.*—Examples of these are rare; Poinsot has collected eleven cases in which the tumors were seated upon the median nerve or other nerve of the arm (A. Bonnet, Piorry, Roux), upon the sciatic nerve (Louis), upon the posterior tibial nerve (Dupuytren, Van der Byl, Dolbeau, Polaillon), upon the pneumogastric nerve (Sottas), or upon the great splanchnic nerve (Lobstein).

(2) *Multiple Neuromata of a Region.*—These have been especially observed in the upper extremities, and upon the cutaneous filaments of the forearm and the hand; such was their seat in the cases of Stromeyer, Robert, Jacquart, Blasius and Volkmann, Blasius, Lebourcq, Huguier, and Nélaton. E. Home met with them upon the brachial plexus; Lanelongue (of Bordeaux) upon the median and ulnar nerves at the upper part of the forearm; Gunsburg upon the branches of the sacral plexus; Virchow upon the saphena nerves; and Heinenche upon the intercostals.

Virchow and Poinsot connect with this variety of multiple neuromata the plexiform neuromata which have already been described.

II. Neuromata of General Multiplicity.—In this variety, the tumors may be met with in different regions and upon various nerves. Cases of this kind are yet quite rare; Poinsot has been able to collect thirty-one. This disease is not a malignant, infectious one, and the tumors are of a benign nature. They have been most frequently met with upon the spinal nerves at the surface of the body, but they may also be seated upon the cranial nerves, in the nerve roots, in the cranial and spinal cavities, and, finally, upon the great sympathetic nerves. Multiple neuromata are frequently congenital and hereditary, as I have been able to determine in several members of one and the same family.

The structure of multiple neuromata varies: These tumors are most often fibromata, and in the case of a patient under my observation, whose case will be again referred to, this was the nature of the growths.

*Symptoms of Multiple Neuromata.*—Three stages should be recognized in the course of these lesions. In the *first*, which may be of very long duration if the tumors are congenital, the disease is unnoticed; it does not manifest its presence by any symptom, though sometimes tinglings and pains precede the appearance of the tumors. In the *second* stage, the tumors appear, and may be accompanied by disturbances of sensibility and motility. In the *third* stage, the general condition becomes worse, and death may supervene.

*Symptoms of Second Stage, or Stage of Tumors.*—Tumors are seen in different parts of the body, upon the course of the nerve branches; they present a

variable bulk, and are not generally the seat of any pain. In other cases there occur disturbances of sensibility and motility. These have been summarized, so to speak, in a case under my care for the past two years.

A man, twenty-one years old, entered the Laennec Hospital during my service of June, 1880. At the age of nine years it had been noticed that he had upon the upper part of the right thigh a tumor of the size of an egg, and soon other very small tumors were seen upon the neck and thighs. In 1879, he had, without any known cause, an orchitis, which terminated in atrophy of the testicle. A few months after, the tumor of the thigh having increased, it was removed. It was considered to be of a fibro-plastic nature; but afterwards was recognized as having for its origin a nerve-tumor like those which existed in great number upon other parts of the body. The wound caused by the operation healed, but the disturbance of sensibility and motility remained. It was at this period that I saw the patient. Fusiform tumors in great number were found along the course of the nerves, tumors which were painless and mobile, and which occupied the thighs, the abdominal wall, the upper extremities, the neck, the occipital nerves, the face at the mental foramen, etc. Pressure upon these tumors produced a sensation of numbness and tingling.

Similar tumors very probably existed upon the deep branches and in the spinal cord. Indeed the patient presented, as has been said, disturbances of sensibility and motility, a sensation of numbness and tingling in both upper and lower extremities. Muscular paresis was also observed, and at the same time very painful cramps and contractures which maintained the limbs in a state of flexion. There was also atrophy of the muscles. These symptoms continued more than three months, and then gradually disappeared under the influence of bromide of potassium, in the dose of 5 grammes (gr. lxxv.) daily. The patient was able to work for a year, but was then obliged to re-enter the hospital on account of the cramps and contracture; some of the neuromata had acquired the size of small almonds, and had become painful; I removed them, and administered the bromide of potassium. All the symptoms again disappeared, and since that time the patient has pursued quite a laborious occupation in the hospital.

On the other hand, I have observed a patient who has had for a long time small elongated tumors of the size of a pea along the course of the nerves in different regions, without these determining any symptom; they have also preserved their small size.

*Symptoms of Third Stage.*—We have seen that, in certain cases, multiple neuromata are not accompanied by any symptoms, and do not affect the health; in others, on the contrary, this is seriously injured, and death may supervene in consequence of the intensity of the pains and of the disturbances of nutrition. Poinsot designates this period as that *of wasting.*

There is another complication which has been noted in several cases, including my own; one of the neuromata undergoes a rapid increase, and may become a fibro-plastic or sarcomatous tumor. Virchow has reported a case in which neuromata of the upper extremity successively experienced this transformation, ultimately necessitating amputation of the arm. It must be noted that in several cases, as in that of my patient, the principal tumor has been seated at the upper part of the thigh.

Connection of the Tumor with the Nerve.—The connections of the tumor with the nerve upon which it is seated are variable, and may be determined by the point of origin of the neoplasm, according to whether it arises in the neurilemma, in the perineurium, or in the intra-fascicular connective-tissue bundles.

Virchow says that he has observed independent, hyperplastic neuromata without connection with the neighboring nerves; in a case of Lebourcq's, the tumor was connected to the nerve by a pedicle; in other cases it has simply touched the nerve.

The tumor is often developed in the thickness of the nerve, of which it

seems to be a regular dilatation, more or less fusiform; the nerve fibres have then an arrangement which varies according to the particular case (Lebert, Michon, Verneuil); they may be separated and pushed over to the periphery of the tumor for which they form an envelope (Velpeau, Lanelongue). There are cases in which the tumor seems to be spitted upon the nerve; sometimes the nerve is found situated in a groove upon the tumor, an arrangement which permits the nerve-trunk to be readily dissected out, as was done by Duncan and Velpeau; sometimes the nerve is lost in the midst of the morbid tissue, as in a fibroma of the median nerve reported by Wietfeldt; sometimes, finally, it is spread out on the deep surface of the tumor (Foucault).

It was upon these relations of the tumor to the nerve, that Lebert based his classification of neuromata into (1) the peripheral neuroma; (2) the interfibrillar or central neuroma; (3) the lateral neuroma; and (4) the diagonal neuroma, in which the nerve traverses the tumor, no longer following its long axis, as in the central neuroma, but pursuing a diagonal course.

What is the state of the nerve below the tumor? Does it undergo the Wallerian degeneration? The latter probably exists when the continuity of the nerve has been destroyed, as in Wietfeldt's case. But in many instances there has been found no alteration of the nerve beyond the tumor (Vulpian); this was the condition in Trélat's case, and in my own case of multiple neuromata. Houel has noticed a lengthening of nerve-trunks which have several tumors upon their course, causing them to pursue a serpentine track, analogous to that of varicose veins.

Etiology of Neuromata in General.—Our knowledge of the etiology of neuromata and of nerve-tumors, is very limited. According to the researches of Poinsot, neuromata, including under this name all tumors of nerves, are more frequent in men than in women. They are met with at all ages; they may be congenital or may occur in old age; they are most frequent in men between the ages of twenty and fifty years, and in women between the ages of ten and forty years (Poinsot).

The cause of the development of these tumors is most often unknown, except in the case of the so-called traumatic neuromata (Smith); an inflammation of the adjoining tissues may also cause the production of a tumor. Fuhrer, cited by Virchow, saw, upon a limb amputated for caries of the wrist, a neuroma of the median nerve, seated at the level of the diseased part.

An increase in the size of the nerves has been noted in elephantiasis, in myxœdema (Hanrot), and in leprosy. Brown-Séquard insists upon the constant presence, in leprous subjects, of a tumor of the ulnar nerve, but Foucault did not find it in eight patients whom he examined.

It is also admitted that syphilitic gummata may form upon nerve-trunks. Lebourcq reports a case of neuroma which disappeared under treatment with iodide of potassium.

Virchow divides neuromata according to their origin into *congenital*, *traumatic*, and *spontaneous* neuromata.

Symptoms of Nerve-Tumors.—Frequently the tumor is developed slowly without giving any manifestations of its presence, and is only discovered when it has reached a certain size; in other cases its appearance is preceded by numbness or by pain. The tumor is situated over the course of a nerve, and is more or less readily detected according to the seat of the nerve which it occupies; it has been mentioned that the superficial nerves are more often affected than others. The tumor is generally oblong, ovoid, rounded, smooth, resisting, and with a certain elasticity. Its size varies very much, and it

may attain considerable dimensions—the size of the fist, for example—but then presents some transformations; it no longer exhibits the same regular shape, nor a uniform consistence. The tumor is movable in a plane perpendicular to the direction of the nerve, without change of the color of the skin.

Pressure upon the tumor, which is sometimes painless, quite often determines numbness, tingling, and pains which are at times violent. Pressure exerted upon the nerve above the neuroma permits the latter to be examined without the patient experiencing pain. Spontaneous pain appears when the tumor has acquired a certain size; it varies in its character, duration, and intensity, and occurs in paroxysms under the influence of atmospheric changes, the heat of the bed, movements, etc.

Motility may be affected in the territory of the diseased nerve; these are muscular twitchings, cramps, and contraction. Occasionally all the muscles of a limb are affected at the same time. These painful paroxysms have been followed by general convulsions, and in one case the paroxysm presented the characters of angina pectoris (Cayzengues).

Generally, neuromata do not cause nutritive lesions of the limb; we have seen above that there is no degeneration of the nerve beyond the tumor.

Diagnosis.—The recognition of *isolated neuromata* may present some difficulties; they are generally fusiform, and seated upon the course of a nerve; quite often they are accompanied with pain, and compression of the nerve above the tumor causes the pain to disappear. A neuroma might be readily confounded with a *partial peri-neuritis* with inflammatory neoplasia; but this is seldom met with. A *fibrous tumor* is indolent, and does not occupy exactly the course of a nerve; a neuroma could hardly be confounded with an *aneurism.*

If the tumor be deeply placed, the diagnosis may be impossible; such was Bérard's case, in which a neuroma of the phrenic nerve gave rise to the symptoms of angina pectoris.

After having recognized that the tumor is seated upon a nerve, it is necessary to inquire what is its nature, but this is most often impossible. It will be seen hereafter how, in the majority of cases, a neuroma may be distinguished from a *painful subcutaneous tubercle.*

*Plexiform neuromata* are seen at birth, or during early life; they have a peculiar appearance, and can be recognized without much difficulty. The same may be said as regards the diagnosis of *multiple neuromata.* They are to be distinguished from the small, subcutaneous *fibromata* which are met with in rheumatic patients, and which are scattered at random, or collected around the articulations. *Subcutaneous lipomata* are occasionally multiple, small in size, and symmetrical; but the shape of the tumor is not regular, it often adheres to the deep surface of the skin, and does not follow the course of the nerves; it is always indolent. The diagnosis from the *subcutaneous nodules caused by the presence of the cysticercus* may be more difficult; sometimes there are found upon a limb several small, oblong, movable, indolent, subcutaneous tumors, which might be mistaken for multiple neuromata of a nerve or of a region. In case of doubt, it would be proper to remove one of the tumors, when the presence or absence of a cysticercus would decide the diagnosis.

Finally, multiple neuromata must not be confounded with the tumors of *disseminated cancer* of the skin.

Prognosis.—The *prognosis* of neuromata is very variable, as has been seen. Sometimes it is favorable; in other cases it is grave on account of the inten-

sity of the pains which they determine, or of the modifications which one of the tumors may undergo. In multiple neuromata, the prognosis is generally serious.

Treatment of Neuromata.—This may be divided into the medical and the surgical treatment:—

(1) *Medical Treatment.*—This has but little effect upon tumors of nerves, except in the case of syphilitic gummata. But it is often very efficacious in relieving the symptoms of neuromata, especially the pain. This often depends upon the general state of the patient, whether arthritic, malarial, syphilitic, or neurotic, and an appropriate treatment may then cause it to disappear. Ice has been employed as a local application, and antiphlogistics have been used; in the case of my patient with multiple neuromata, I obtained the disappearance of all the symptoms, except the presence of the tumors themselves, by giving large doses of bromide of potassium.

(2) *Surgical Treatment.*—This is indicated when medical treatment has failed, and is directed against large, fibrous or sarcomatous tumors of nerves, or against those which are the seat of sharp, insupportable pain.

The importance of the nerve is not a contra-indication, particularly as in a certain number of cases the operation has been followed by a re-establishment, more or less complete, of the functions; the existence of several tumors is not always a contra-indication. Sometimes, in cases of multiple neuroma, one, two, or three tumors are painful, while the others remain indolent; the painful tumors should then be removed. In the case of the patient of whom I have already spoken, I have thus performed several operations, and at the present time he enjoys perfect health.

*Operations employed for Nerve-Tumors.*—The *cauterization* of nerves and nerve-tumors, practised in former times, and recommended anew by Legrand, in 1858, is almost never employed at the present time. Recourse may be had to the following procedures:—

(1) *Enucleation.*—Virchow divided neuromata into *complete* and *partial* neuromata, according to whether all or part of the nerve-fibres were implicated in the neuromatous process. In the partial neuromata, the tumor, occupying only a portion of the nerve-trunk, may be removed by enucleation without injuring the healthy part of the nerve. For this purpose, the tumor having been exposed, its connections with the nerve are examined, then the neurilemma which covers the tumor is incised, and an attempt is made to dissect out the growth from the nerve, since if even a few of the nerve-fasciculi are uninvolved, it is desirable to preserve them, in order to facilitate the regeneration of the nerve and the re-establishment of its functions (Roux, Velpeau, Bickersteth, Letiévant, Lanelongue). If the tumor has a groove excavated in it, which incloses the nerve, the operation is easy; it is the same if the case is one of lateral or pedunculated tumor (Voillemier, Lebourcq). If it is possible, there should be left a portion of the nerve, when the tumor is non-malignant; but if it is a sarcomatous tumor, for example, the nerve should be resected at a higher point.

(2) *Extirpation.*—This is the operation most frequently adopted; all the diseased portion of the nerve is removed, care being taken to make the first section of the nerve above the neuroma, in order to diminish the pain and reflex phenomena. After the operation, an attempt is made to approximate the ends of the nerve by position or by suture (Nélaton, Notta). Extirpation is also recommended in cases of plexiform neuroma.

(3) *Neurotomy.*—When the nerve is so deeply situated that it cannot be reached, or that the operation presents too many dangers—or even if several

tumors are seated upon the same nerve—section of the nerve above the tumor has been practised in several cases, in order to cause the disappearance of the pain. Resection of a portion of the nerve-trunk has also been done in similar cases, instead of a simple neurotomy. The same practice has been advised in cases of secondary cancer of painful and inaccessible nerves.

(4) *Amputation.*—Finally, amputation has been practised in cases of painful multiple neuromata of one and the same region (Smith). In cases of this kind, Arloing and Tripier prefer multiple and associated sections of the nerves, made at the root of the limb. In a case cited by Virchow, amputation of the arm was resorted to for multiple nerve-tumors which were thought to be of a fibro-plastic nature, but which, says Virchow, were nothing but neuromata.

Painful Subcutaneous Tubercle.—Under the name of painful subcutaneous tubercle, there has been described since the time of William Wood, who made the first serious study of it,[1] an affection characterized by the existence of a small subcutaneous tumor, of which the principal characteristic is to become extremely painful under the influence of different causes. This affection has further been designated under the names of *irritable tumor*, *ganglion*, *painful subcutaneous fibroma*, and *painful neuroma* (Virchow).

The nature even of the tumor which causes the painful symptoms is variable, as we shall see, and it may be asked whether the painful subcutaneous tubercle should be considered and described as a distinct disease, or whether the symptoms which characterize it are not rather accidental phenomena, which may occur to complicate the evolution of different tumors more or less immediately subcutaneous, and which may appear under the influence of causes yet unknown. We shall limit ourselves to proposing this question, the solution of which demands special researches that do not properly belong to an article of this kind, and shall then pass immediately to the clinical study of this affection, and to an exposition of the different views which have been set forth as to its pathological anatomy and nature.

*Etiology.*—Painful subcutaneous tubercle is particularly observed during adult age, from thirty to fifty years. All authors remark its greater frequency in women, and, in certain cases, the coincidence of the beginning of the pains or exacerbations with the menstrual period, with pregnancy, or with the menopause—all circumstances which increase the nervous excitability—so that Broca was able to say that it was the patient who was irritable rather than the tumor. As to traumatism, frequently invoked by patients as in the case of all tumors, its influence is doubtful; perhaps, however, it contributes to the development of the painful symptoms by irritating a tumor which has been previously indolent.

As a local cause, the seat of the small tumor plays, perhaps, an important part; indeed, we shall see in studying the pathological anatomy of this affection, that it is most frequently met with in regions where the skin is in direct relation with the bones and articulations.

*Symptoms.*—Pain and tumor, these are the two symptoms of this affection; but they are not ordinarily developed at the same time. Sometimes it is the pain which shows itself before any tumor is appreciable; more often the tumor appears first, and only becomes painful after a longer or shorter period, either in consequence of a traumatism, or spontaneously. The disease once constituted, there is observed a small tumor, which seldom exceeds

[1] Edinburgh Medical and Surgical Journal, 1812.

the size of a pea or bean, subcutaneous, or forming more or less a part of the deep surface of the derm, and consequently more or less movable, hard, smooth, round, and accompanied sometimes with modifications of the skin which will be again referred to. The slightest handling of this tumor provokes an explosion of painful, neuralgia-like paroxysms, accompanied with centrifugal or even centripetal irradiations, and having an intensity and variable duration according to the particular case. Strong pressure may, on the contrary, not determine painful paroxysms. In the interval of these paroxysms all the painful phenomena generally disappear.

Pain is not only provoked by the examination of the tumor, and by the contact and friction of the clothes, but it is further determined by movements of the part, or by muscular contraction, and supervenes even, especially when the affection has lasted for a certain time, from inappreciable causes.

According to Bouchage, who reports in his thesis a minutely analyzed case of painful subcutaneous tubercle, there may be distinguished two varieties of pain, so to speak, which are due, the one to the general sensibility, which is increased at the seat of the tumor, the other to the special connections which the tumor has contracted with the smooth fibres of the deep surface of the derm and the surrounding small nerve-filaments. After a sudden blow upon the tumor, for example, the first variety shows itself by an immediate and temporary pain, and the second by the characteristic painful paroxysm which is delayed a few moments after the excitation. It is upon this kind of incubation of the painful paroxysm, that the author has based a pathogenic theory which will be hereafter explained.

The paroxysm presents great variety according to the patient: sometimes it is a bearable pain, which scarcely disturbs the patient a few minutes from his occupation; sometimes it is a more acute suffering, which may last several hours; sometimes, finally, the paroxysm is sufficiently violent to provoke syncope, or to be accompanied by epileptiform convulsions.

In a certain number of cases there are noted, at the moment of the paroxysm, changes, of which some affect the tumor itself, and some the skin which covers it. As regards the tumor, there has been noticed a kind of turgescence, or an increase in consistence, and a greater adherence to the skin (Bouchage). In regard to the skin, it is congested and reddened, according to some authors, during the paroxysm, although in Bouchage's case paleness replaced at this moment the violet color which it had in the intervals between the pains.

*Course.*—We have seen that the tumor in most cases exists before the appearance of the painful paroxysms. This period of painlessness may be quite long, and may last even for several years. The evolution of the tumor is always extremely slow, and we know that its size does not exceed that of a pea or bean; at first subcutaneous, it ends most frequently by becoming adherent to the skin, which then sometimes assumes a violet color. The painful paroxysms generally follow a slowly progressive course, and have no tendency to a spontaneous recovery; nevertheless, in exceptional cases they have been found to become milder, and to disappear without treatment, at the same time as the tumor. In this connection Windsor's case may be cited, in which a painful tumor of the forearm, appearing after a bleeding, was found to be formed of small, hard granules inclosed in a cystic membrane. The patient was fifty-nine years old, and Bouchage regards the case as an example of cretaceous transformation and segmentation of a fibrous tumor. The pain always yields to the ablation of the tumor, but in certain cases may continue for a time after the operation, and only disappear gradually. Finally, although these tumors do not, properly speaking, recur, yet several may require opera-

tion in the same individual, though it is exceptional to observe more than one at a time.

This affection has no direct influence upon the general health, but it is scarcely necessary to say, that the existence of violent, frequent, and prolonged paroxysms necessarily affects nutrition, and causes a more or less rapid enfeeblement, which, again, facilitates the return of the painful crises.

*Pathological Anatomy.*—It is the pathologico-anatomical study of painful subcutaneous tubercle, which may give rise to doubts in regard to its existence as a distinct disease; in opposition to analogous clinical features, indeed, very different results are obtained by microscopical examination; fibromata, myomata, angeiomata, fibro-mxyomata, true neuromata, chondromata, lipomata, even carcinomata, have, during life, caused symptoms of the affection under consideration. Fibromata, however, according to most authors, constitute the majority of these tumors.

We have seen that painful subcutaneous tumors are generally single; their seat is usually in the subcutaneous cellular tissue, especially at the points where the skin is in direct relation with the bones and articulations; the regions where they have been observed, in order of frequency, are the legs, face, back, fingers, mammæ, and scrotum. But their origin is not always so superficial; in Fock's case, the tumor was implanted upon the periosteum of the tibia, and it was intra-articular in two cases of Busch's. These tumors never reach a large size; they are ordinarily not larger than beans. We have seen that they usually become adherent to the skin after a certain time. Their shape, generally rounded, and their external appearance, vary very much with the nature of the tumor. But these differences are only distinctly appreciable when the tumor is in our hands. When the growth is a fibroma or myoma, the surface is smooth and pearly, the consistence solid and elastic, while the appearance of the section recalls that of fibrous tumors of the uterus. The histological examination shows fibrous elements interspersed with nuclei and a few fusiform, fibro-plastic bodies, or smooth muscular fibres, without any trace of nerve-filaments either in the limbs, upon the surface, or in the interior (Follin, Lebert). The majority of these tumors are, as it were, encysted by a fibro-cellular envelope.

But while admitting the existence of these painful fibromata, it cannot be denied that true neuromata may occasion the same symptoms (Virchow). The tumor may present the characters of the fasciculated neuroma (Labbé and Legros), of a fibro-myxoma inclosing in the midst of its stroma myelinic nerve-fibres (Chandelux), or of a telangiectasic neuroma (Schuh); or it may even recall the structure of a hypertrophied Pacinian corpuscle (Axmann).

Other cutaneous or subcutaneous tumors have also occasioned the symptoms of painful subcutaneous tubercle; I need only cite the case of carcinoma of the skin reported by Dupuytren in his lectures, and two very interesting cases of Busch, where the pain was determined by very small, true, intra-articular chondromata arising some distance from the articular cartilage of the femur in one case, and from one of the phalanges of the thumb in the other. Histological examination showed that these tumors were formed of pure hyaline cartilage, completely deprived of nerves.

*Pathogenesis and Nature.*—It is seen, in short, that the relation of lesion to symptom is not yet well established in regard to this affection, and that it cannot, without forcing the facts, be admitted, with Follin, that the tumor of true painful subcutaneous tubercle is always a fibroma, or positively distinguishable from neuroma, of which it may present the structure. The opinion of Broca is less positive; this author thinks that every subcutaneous tumor

may become irritable, but that the fibromata are so disposed more than all others, on account of their hardness, which irritates the small nervous filaments in their proximity. It would appear that in the actual state of science it is impossible to be more definite without entering the field of hypothesis. This can only be done after having discovered the anatomical reason why one subcutaneous tumor is painful and another is not.

As to the mechanism itself of the production of the painful paroxysm, hypotheses only have been advanced upon the subject. Without speaking of exceptional cases, in which true neuromata have existed, we have seen that the tumor does not present any trace of nerve-elements; the cause of the pain must then be sought for in a neighboring compression or irritation, of which, unfortunately, there is no anatomical proof; there cannot, obviously, be any invasion of the nerve-filaments by the tumor, since this has been in all cases, except Dupuytren's, a benign tumor, which is consecutively developed by simply pushing away the neighboring parts. The general condition of the patient must also be carefully considered. The ingenious hypothesis of Bouchage upon the pathogenesis of the painful paroxysms must also be mentioned. Sustaining himself upon the fact that, in the case which he studied, the adherence of the tumor to the integument was stronger at the moment of the paroxysms, and upon the change in color of the skin, which then became pale in place of remaining violet; and relying also upon the existence of a short period of "incubation" of the paroxysm, this author attributes it to the contraction of the smooth muscular fibres of the deep surface of the derm—a contraction slow in appearing and slow in disappearing, like the paroxysm itself, and acting by pressing the tumor against the nameless nerve-filaments which surround it.

*Diagnosis.*—Careful examination of the painful region will readily enable the small tumor to be discovered, and will prevent this affection from being confounded with *neuralgia.* Most frequently, however, the patient already knows of the tumor, and points it out himself. This differential diagnosis is evidently impossible in the exceptional cases in which pain precedes the tumor, and can only be made upon the appearance of the latter. At most, the possibility of the existence of this affection might be foreseen from the seat of pain being in one of the regions which we have pointed out, and from the absence of all other causes capable of explaining it. We have seen that the painful subcutaneous tubercle may present the structure of a *neuroma*, and we cannot therefore follow Follin in discussing the diagnosis of these two affections, which may be blended; it is evident that painful subcutaneous tubercle would not be thought of in cases of neuromata presenting themselves with their ordinary course in the form of multiple tumors along the known track of a nerve, nearly painless, and with relatively rapid and considerable development; let us add that neuromata are very much more frequent in men than in women, herein differing from the affection which we are considering. But when a painful subcutaneous tubercle is recognized, it cannot be affirmed that it is not constituted by a small, isolated neuroma; indeed, most frequently the nature of the tumor under observation is only known after removal by operation, unless the case is one of carcinoma of the skin, for example, the ulceration and course of which do not leave any doubt.

*Prognosis.*—The prognosis is dependent upon the nature of the tumor; that is to say, it is generally favorable, in the sense that there is no fear either of generalization or of direct alteration of the general health. But, on the other hand, it has been seen that a spontaneous disappearance of the pains is not to be counted upon, and that, on the contrary, they generally continue

increasing; it is then necessary to interfere if they are so severe as to prevent the patient from continuing his occupation, and still more, if their duration and frequency threaten to impede nutrition. Moreover, weakness facilitating the return of the paroxysms, the situation may, indeed, become grave, and may terminate in a true cachexia (irritable weakness).

*Treatment.*—The therapeutic indications are, perhaps, the only points well established in the history of painful subcutaneous tubercle. All authors agree in recognizing that *narcotics* are powerless to cause recovery, and constitute only a palliative medication of a duration necessarily limited, on account of the digestive disturbances caused by their prolonged employment. If the pains are not intense, the paroxysms may be rendered less frequent by the patient wearing a *protective covering*, as recommended by the authors of the *Compendium de Chirurgie*, but the only curative treatment is ablation of the tumor, which is ordinarily followed by complete recovery. In certain cases, however, the pains have persisted after the operation, and have only gradually disappeared. Caustics should not be used in this operation, but the little tumor should be removed with cutting instruments; in no case has the cicatrix become the starting-point of new pains.

## Tetanus.

Definition.—Tetanus is an affection characterized by a permanent and painful contraction of the majority of the voluntary muscles, which habitually begins in the muscles of the jaws and of the neck, gradually extends to the other muscles, and is accompanied by convulsive paroxysms.

Tetanus may be *traumatic* or *spontaneous* (tetanus *a frigore*, rheumatic tetanus); *chronic*, *acute*, or *subacute; continuous*, *discontinuous*, or *intermittent;* finally, it may affect different muscular groups. The name *trismus* is given to the contraction of the elevators of the lower jaw; *opisthotonos* to that of the extensors of the neck, trunk, and inferior extremities (this is the most frequent variety); *emprosthotonos* to that of the flexors; and finally, *pleurothotonos* to that form which is constituted by the contraction of the muscles which draw the vertebral column laterally; this last variety is very rare. Lastly, tetanus is called *tonic* when the spasm affects all the voluntary muscles (Follin).

Etiology of Tetanus.—All traumatisms in all conditions, with or without wound, may be complicated by tetanus. It must, however, be recognized, as it is by all authors, that it seems to supervene most frequently after contused wounds of the extremities, feet or hands, of the scalp, and, generally, of regions where the Pacinian corpuscles abound (Gubler). The seat of the wound may then have a certain influence upon the production of tetanus, but the gravity and extent of the wound have none. Tetanus has been seen to occur after subcutaneous injections of sulphate of quinine, or dilatation of the neck of the uterus with a sponge tent, as well as after the most grave traumatisms. In certain cases, however, a sufficient cause is found in the wound itself, to explain the production of the malady; lesions of the nerves, a foreign body inclosed in a nerve, painful granulations, or a cicatrix including a nerve extremity. Most frequently it is not in the wound itself that the principal cause of tetanus is to be sought for, but in the state of the patient and in the conditions by which he is surrounded. Age, sex, alcoholism, and even the puerperal state, which is invoked by some authors, appear to be without influence; it is not the same as regards *malaria*, which seems to predispose to

tetanus. (Intermittent fever of a tetanic form has even been described.) *Race* especially seems to play an important part, tetanus being more frequent and more grave among negroes, independently of climatic influences. Finally, *inheritance* was invoked in a case of Metzger's. But the most important condition is *individual predisposition*, a vague cause which we are forced to admit in view of the disproportion which exists between the number of instances of tetanus, and that of cases which unite the conditions believed to be sufficient to provoke this affection. When we shall have mentioned the condition of over-work, and that of moral depression, which have been sometimes invoked with probability, it will only remain for us to speak of the *surrounding conditions* which play a very important part, and the most important of which is cold. *Cold*, moist cold, and especially sudden variations of temperature—which explain the frequency of tetanus in certain climates with high temperature, Cayenne for example—are occasional causes, admitted by all authors, which may be sufficient (tetanus *a frigore*), but which are not met with in all cases. Nothing is more convincing than the case cited by Mirbeck, of that American infant who died of tetanus four days after having received, full upon its chest, a glass of iced water, being in a sweat. It is through the influence of joint causes, cold and moral depression, upon the wounded who remain upon a battle field (the battle of Bautzen, for example), that the epidemics of tetanus which are sometimes observed are generally explained. Some authors admit the possibility of *contagion*, of *poisoning*, as in surgical septicæmia. Betoli reports the case of slaves who died of tetanus after having eaten the flesh of a bull which had perished from this affection. This latter mode of transmission is admitted, it seems, in certain regions of America.

Pathological Anatomy.—The lesions characteristic of tetanus have been successively sought for in the spinal cord and its envelopes, in the brain, in the nerves near the wound, and finally, in the muscles. We shall briefly pass in review the principal results of the autopsies which have been made, and shall see what conclusions may thence be derived.

The *brain* is generally healthy; there have been described, congestion of the meninges, convolutions, pons, tuberculæ quadrigeminæ, and corpora striata, colloid degeneration of a part of the cerebellum, and, in one case, tumor of the cerebellum (Jackson); upon the whole, nothing constant. The *meninges* of the *medulla oblongata*, which are sometimes found irritated or even inflamed, are more often normal.

It is upon the *spinal cord* that investigations have been especially concentrated, and it is also here that lesions have been most frequently found. The facts which have been observed may be arranged in three classes. In the first are placed the negative cases, where the spinal cord does not present any change after death, although the histological examination has been made by observers of unquestionable authority; in the second class are the cases where only a simple hyperæmia has been established, especially marked around the bulbar nuclei of the cranial nerves, and around the canal of the ependyma and of the roots of the nerves going to the injured region. Finally, the third class includes the positive lesions: nuclear proliferation in the reticular substance, and a return of the cellular elements to the embryonal state, whether by modification of the protoplasm or by degeneration of the cells; plates of granular degeneration of Lockhart Clarke, which are, according to Michaud, foci of perivascular exudation; colloid degeneration, etc.; in short, *myelitis*, more or less advanced, occupying especially the regions of the spinal cord in which congestion has been noted in other cases (hyperacute central myelitis of Charcot and Michaud).

As peripheral lesions there have been found a certain number of times a redness of the neurilemma of the *nerves* which correspond to the wound, and even a more or less extended *ascending neuritis*, perhaps most frequent when the tetanus begins at the wounded part; but more often the nerves are normal, like the *muscles*, which have also sometimes presented a beginning of interfascicular sclerosis or of waxy degeneration, without speaking of the effusions of blood and ruptures due to their excessive contractions. We must mention finally the cases where the cause of the tetanus has been evidently a *foreign body* remaining in the wound, or inclosed in the nerve itself, as in the classical case of Dupuytren's where the knot of a whip-lash was found in the ulnar nerve. Lastly, inflammatory lesions have also been noted in the great sympathetic.

To recapitulate: The most frequent lesions are those of the spinal cord, but even these may be absent. It must, then, be admitted that the anatomical condition of tetanus is a simple irritation of the nerve-elements, perhaps a slight congestion, which leaves no traces after death, but which may terminate, if it is prolonged, in a permanent hyperæmia, a consequence and not a cause of the exaggerated activity of the nerve-cells (Vulpian); with still more reason should the deeper lesions that we have described be considered as secondary.

Nature and Pathogenesis; Pathological Physiology.—What is the nature of tetanus? Without speaking of the theory of Stutz and Martin de Pedro, who located the disease in the muscular apparatus—a theory which would seem very difficult to maintain—all authors agree in considering it a pathological reflex condition, with exaggeration of the activity of the spinal cord. But when these vague terms are set aside, the agreement is soon broken, and there are almost as many explanations as authors in regard to the nature of primary peripheral irritation, and the path by which it is transmitted to the spinal cord. The opinions which have been put forth may be divided into two classes, one admitting an alteration of the blood which directly determines the exaggerated activity of the cord (humoral theory), while the other finds in the nerve-trunks the agent which receives and conducts the initial irritation (nervous theory). We shall successively set forth these two theories.

(1) *Humoral Theory.*—The alteration of the blood which is considered the determining cause of tetanus, has been compared to that which is produced by poisoning with strychnia, or to that which produces rheumatism, the determination of the lesions upon the spinal cord, rather than upon the articulations or other viscera, belonging therefore to an individual predisposition. Others, seeking for the origin of the alteration of the blood, have made it the result of a partial poisoning from the wound, or of an autochthonous septicæmia determined by the sudden suppression of the functions of the skin, and the passage into the blood of its excretory products; finally, Trevisanello supposes it to be produced by a specific element, making tetanus an infectious disease—an opinion against which may be advanced the negative results of the inoculations hitherto practised. Independently of the mechanism of the alteration of the blood, there have been invoked in favor of the humoral theory, the elevation of temperature analogous to that of septic diseases, but not constant; the epidemic character which tetanus may assume, and which may result from the simultaneous action of the same causes; and, finally, the existence of an intermittent fever of tetanic form. At all events, the few recoveries unquestionably due to neurotomy and to the removal of cicatricial constriction by incision, show that this theory is not applicable to all cases.

(2) *Nervous Theory.*—The primary irritation has been located in the muscles or in the extremities of the nerves themselves. Forbes explains it by an excess in the production of creatin and lactic acid in consequence of an exaggerated muscular degeneration, which is itself dependent upon an excessive nervous activity which he leaves unexplained. The advocates of the theory of the primary irritation of the extremities of the nerves, admit that this may be produced in the wound in a variable and often undetermined manner, and they have to sustain them a certain number of cases where this cause is unquestionable (foreign bodies, defective cicatrices), and where the success of neurotomy, of amputation, or of incision of a cicatrix, has distinctly demonstrated its action.

Whatever may be, however, the theory that is adopted, in view of the great number of wounds and causes of chilling, and of the rarity of tetanus, we are obliged to consider the appearance of this affection as dependent upon an individual predisposition, impossible to ascertain or even to suspect beforehand.

The irritation, once transmitted to the spinal cord by the nerves or the vessels, determines there an increase of reflex power, which betrays itself only secondarily by morphological lesions appreciable by our means of exploration. The mechanism of this increase of reflex power of the spinal cord is yet disputed, some regarding it simply as increased functional activity, while by others it is thought due to paralysis of the moderator centres of reflex action, of which Vulpian contests the existence, or, finally, as believed by Ringer and Murrell, to a diminution of the *resistance* of the spinal cord, this word designating a force which tends to locate peripheral stimuli in a given segment of the cord, and to regulate the nervous discharge.

This excitation of the spinal cord is manifested clinically by two sets of symptoms, the one constant—the more or less generalized muscular contraction—and the other inconstant and variable, the increased temperature, as to the pathogenesis of which authors have expressed different opinions. Its production has been attributed to asphyxia, which it often precedes for some time—to the presence of a complication which is not met with in every case where an elevation of temperature is observed—and to a septic change in the blood, in favor of which its existence is an argument. A view more attractive at first sight, is that maintained by Muron, which explains the high temperatures of tetanus by the heat liberated by the muscles in tonic contraction; but, apart from the fact that a generalized tetanus may not be accompanied by an elevation of temperature, the highest temperatures are not always coincident with the paroxysms in the same patient, and are not proportional in different patients to the intensity and to the generalization of the muscular contractions. Finally, this hypothesis does not explain the elevation that is sometimes seen after death, and which may, according to Wunderlich and Leyden, exceed 2.5° C. (4.5° Fahr.).

There remains a view which seems acceptable, and which makes the increase of temperature depend upon the exaggerated spinal activity itself, which produces it by accelerating beyond measure the interstitial combustions; these may in certain cases maintain the impulse which is given to them, so to speak, and may continue to elevate the temperature some time after death. A very useful element of this investigation would be a thorough knowledge of the modifications of the blood and urine in tetanic patients, of which unfortunately very little is yet known.

To summarize: tetanus should be considered as a pathological reflex state, having for its point of origin a peripheral irritation of undetermined nature; for its actual condition, an exaggerated functional activity of the spinal

centres without any special lesion; and for its effect, muscular contractions with or without elevation of temperature.

Symptoms and Course.—Tetanus reveals itself by two orders of symptoms of very different importance—one constant and necessary, *muscular contraction*, and the other very variable, and sometimes entirely absent, *elevation of temperature.* Let us first study these symptoms by themselves, with the changes of pulse, blood, and urine, and we shall afterwards see how they are combined and modified, so as to constitute the different varieties of the disease.

The *muscular contraction* characteristic of tetanus, is a *permanent, tonic convulsion, with paroxysms;* but it does not, at the first onset, present itself in this form. Each group of muscles contracts at first in an intermittent manner, at the moment of the general paroxysms only, and is completely relaxed in the interval; then the contraction becomes continuous, with an increase at the moment of the crises, and it is under this form that it persists the longest; finally, in exceptionally grave cases, the tonic contraction may be so energetic that the crises do not sensibly influence it. When recovery is about to occur, the permanent contractions again alternate with complete remissions before disappearing, and, finally, show themselves only with voluntary movements. At this period of decline the convulsions are less easily provoked by external excitation, and do not continue as long as during the periods of the disease's increase and height.

The *temperature* may remain normal, or nearly so, even in the most acute cases; when it is elevated it has no defined cycle, and may present all variations, without necessary relation to the gravity of the disease and the intensity or generalization of the muscular contractions—without, in fine, the maxima constantly corresponding to the paroxysms; the evening increase is not observed as in most acute diseases. These restrictions made, it must be said that, in very acute cases, the most frequent course of the temperature is the following: It is at the outset 39° C. (102.2° Fahr.) in the axilla, and the increase continues, with or without oscillations, until it exceptionally reaches (Wunderlich), at the moment of death, 43°, or 44.75° C. (109.4° or 112.5° Fahr.); the temperature may sometimes be further elevated after death, and the same observer has seen it reach 45.3° C. (113.5° Fahr.) in these conditions. In other cases, on the contrary, death is preceded by a lowering of the temperature.

The *modifications of the pulse* seem to correspond more exactly with the course of the disease and with the paroxysms; from 80 to 120 in mild cases, the number of pulsations may be increased to 150 and 160 in the grave cases; according to other authors, however, the curve of the pulse is pretty closely parallel to that of the temperature.

Finally, in regard to the *modifications of the urine and of the blood*, in the writings of the few authors who have studied these, there are found only contradictory results; the amount of urea, for example, is increased according to some, and diminished according to others. The analysis of these liquids in tetanic patients would furnish, however, an important foundation for the study of the pathological physiology of the disease.

*General Type of Tetanic Symptoms.*—In the first fifteen days which follow the injury, without any precursory sign on the part of the wound—such as dryness, bad appearance, or arrest of cicatrization, to which formerly were attributed some importance—the patient is seized with a slight trismus, which still permits a little separation of the jaws, but which is increased if we attempt to overcome it, and which is accompanied by a particular aspect of the physiognomy, by a look of contentment of which the exaggeration con-

stitutes the *sardonic laugh*. The next day, or a few days after, the trismus becomes marked, and the jaws can only be half opened between the paroxysms, which come nearer together; the muscles of the face become involved, and give to the physiognomy the expression of the *risus sardonicus*, of which we have just spoken. The disease is established, and the generalization of the contraction is brought about, in a nearly determined order; the extensors of the neck contract, causing an embarrassment of the movements of the nucha, which may be more precocious, and which may constitute, with the trismus, one of the initial symptoms; the lower limbs become stiff, adducted and extended; the contraction of the abdominal muscles hollows and hardens the belly, and the extensors of the vertebral column curve it more or less backwards, thus producing *opisthotonos*. The upper extremities are spared in mild cases, but invaded more or less rapidly in grave cases; the spasm is then generalized, except as to the diaphragm and muscles of the larynx, upon the integrity of which depends the life of the patient.

Besides this *contraction* of the muscles, which soon becomes continuous, and is already painful, there are observed, at gradually diminishing intervals, *very painful paroxysms*, which supervene under the influence of the least external excitation, or even without appreciable cause. The contraction of the muscles already attacked is increased, and the spasm seizes the groups still relaxed, those most affected remaining contracted, while the others relapse into resolution until the following crisis; the patient remains silent, or utters inarticulate groans, and sometimes actual cries.

Frequently these crises are accompanied with more or less abundant *sweatings*, which are considered as favorable, and which an effort is made to promote, as we shall see hereafter; the patient ordinarily takes with pleasure such food as the spasm of the jaws and of the pharynx permits him to swallow between the crises. *Insomnia* and *constipation* are habitual. In regard to the bladder, there is frequently observed *dysuria*, sometimes complete *retention* which it is necessary to watch. *Cutaneous eruptions* have also been described in some cases, but are probably due to the medication with chloral or opium. The *intelligence* remains habitually perfect until the end; delirium is always a very grave symptom, and often coincides with a high temperature. Death is, unfortunately, the too frequent termination of the disease, but recovery is also possible; we shall recur again to these modes of termination.

*Varieties.*—The form which we have described, and which is the average type of traumatic tetanus, is susceptible of numerous modifications, the principal of which constitute varieties of tetanus which we shall successively study, and of which the distinctive characters result from (1) the etiology, (2) the mode of onset, (3) the degree of generalization, and, finally (4) the duration of the disease.

(1) In accordance with the *etiology* of the affection, there may be distinguished *traumatic tetanus without wound*—consecutive to fractures, luxations, violent contusions, etc.—scarcely distinct from the form already described, but beginning more often by phenomena referred to the seat of injury, and ordinarily slower and more benign; and *spontaneous tetanus* from cold (*a frigore*)—so-called rheumatic tetanus—the onset of which may be either sudden or insidious. This may be preceded for from one to eight days by the prodromes of febrile disease, *malaise*, lassitude, and chills, accompanied by symptoms which should arouse the surgeon's attention—dysphagia, tendency to an exaggerated extension of the limbs and of the trunk, especially at night, and pains along the spine. The beginning of the contraction occurs here also in the elevators of the lower jaw, though it has been sometimes observed in the lower extremities (Bouchut); otherwise the course of this disease differs in nothing from that of traumatic tetanus, but in Europe,

contrary to what has been observed in warm countries, it is less dangerous than that affection.

There remain two varieties of tetanus of special etiology, the *tetanus of the new-born*, and *puerperal tetanus*. Let us first dismiss the latter, which presents nothing special; it is a traumatic tetanus consecutive to a uterine wound, as it is observed, though seldom, after traumatisms of the non-gravid uterus—ablation of mucous polypi, dilatation of the cervix, etc.; perhaps we should take into consideration, as a predisposing cause, the physical and moral depression which especially follow abortion.

In regard to the *tetanus of the new-born* (*trismus neonatorum sive nascentium, locked jaw*), its nature is very obscure, and even its existence is disputed since the labors of Parrot, who has demonstrated that, in our climate at least, the affection which had been described by previous writers under this name, was only a form of eclampsia due to uræmic brain-disease. Its symptoms, moreover, differ from those of true tetanus; it begins about the end of the first week after birth; the child is restless, cries, and vomits; its dejections are greenish; its facial expression pinched; and its lips earthy; then the spasm occurs, at first upon the face, next at the nucha and at the back, manifesting itself by cramps and clonic convulsions which terminate in collapse; finally, dysphagia supervenes and the child dies in coma or during a paroxysm. It is possible, however, that there exists in warm countries a true tetanus of the new-born, depending upon the umbilical wound or upon chilling. [According to Marion Sims and P. A. Wilhite, of South Carolina, *tetanus nascentium* is a traumatic affection, resulting from displacement of the occipital or of one of the parietal bones, and often avoidable by changing the child's position, so as to vary the point of pressure as it lies on the bed or pillow.]

(2) The *mode of onset* permits us to distinguish two very important varieties of tetanus, that which begins with trismus, and which we have described, and that which begins at the point of injury, a variety which Follin distinguishes from tetanus under the name of *secondary traumatic spasms*.

The degree of relative frequency of these two modes of beginning is not yet exactly established, but at present there is a tendency to admit that the second is more frequent than the old authors thought, a very important fact in regard to treatment. The onset at the point of injury does not, indeed, always occur with "a sharp shock and intense pain in the injured limb," as said by Follin, the spasms then following at this point and becoming gradually generalized. On the contrary, in the majority of cases of traumatic tetanus, the pains and cramps of the injured limb are not violent; their existence may be overlooked if the patient is not carefully questioned upon this point, and the trismus is then the first symptom *observed*. These *pains at the point of injury* may persist during the whole course of the disease, and precede the crises, constituting thus a kind of *tetanic aura*, the existence of which is the most trustworthy indication for neurotomy or for amputation.

When the onset does not occur at the seat of injury, trismus is not always the initial phenomenon; it was entirely absent in one case, and in another the spasms affected the depressors of the jaw. These peculiarities are of no importance, but it is not so with the primary or rapid invasion of the muscles of the pharynx, which constitutes the *dysphagic form* of tetanus, a variety of very grave prognosis. These are the cases that Rose would have described under the name of *hydrophobic tetanus*. In this connection may be mentioned a case published under that title by Kirchhoff,[1] a case which was somewhat complex on account of the lesions of the corpus striatum found at the autopsy,

[1] Berlin. klin. Wochenschrift, 1879, No 25.

and in which the mere sight of liquids determined a paroxysm of opisthotonos.

In reference to the period elapsed since the reception of the traumatism, the time of onset of tetanus may vary from a few hours to several weeks; sometimes it occurs only after the cicatrization of the wound. The course of the disease is generally the more rapid as its onset has been more precocious.

(3) With regard to the *generalization of tetanus*, the invasion of the muscles of inspiration is of capital importance as regards prognosis, and it is the precocity of this invasion in the dysphagic form, which constitutes its danger. Those cases must also be noted, in which the spasm remains limited to trismus, with or without slight invasion of the lower extremities; these cases belong to the *slow form*, and consequently are usually benign; but an exaggerated confidence is to be guarded against, and it must be remembered that *generalization is always possible*, and that it has been known to supervene and prove fatal after the contraction had remained for several weeks confined to the jaw.

(4) With regard to the *duration* of tetanus, a *rapid form* and a *slow form* have been described, the first being always fatal, and the second always ending in recovery, according to some authors, no matter what be done—a view which seems to be exaggerated, and which will be hereafter discussed in connection with prognosis.

The *slow form*, or *chronic tetanus*—to which variety belong most cases of spontaneous tetanus met with in our climate, and those in which the onset occurs a long time after the injury—runs its course in two months at most. The contraction may invade all the muscles and cause death, sometimes quite suddenly, but more often the termination is favorable, and generalization does not occur. According to Küssmaul there exists an *abortive tetanus*, characterized by its long duration, the mildness of the tonic contractions, their extension to a great number of muscles, and the absence of sudden shocks.

The *rapid form*, which includes *acute* and *hyperacute tetanus*, ends most frequently in death in the course of a few hours or a few days. Bardeleben cites the case of a negro under his care, who died from tetanus a quarter of an hour after receiving a wound of the thumb. The onset is generally not far removed from the period of the traumatism; the pharynx and larynx are soon invaded, as well as the respiratory muscles; and the muscular contractions are from the start permanent, and without complete remissions between the paroxysms, which are very near together. It is in this form that the violence of the contractions may determine muscular ruptures.

Termination of Tetanus.—*Death* is the most frequent termination of tetanus, especially when traumatic, but it is far from being constant, and cases of cured tetanus abound at the present day in medical literature. A fatal termination may be anticipated from the beginning, when the course of the tetanus is very rapid, and when the first spasms are very violent; death then occurs during the first four or five days of the disease. In cases where the progress of the disease is not so overwhelming, the approach of death is generally announced by the elevated temperature, by the delirium, and by the frequency, smallness, and irregularity of the pulse; but it depends especially upon the generalization of the contractions, and in particular upon the invasion of the respiratory muscles, and perhaps of the heart. The most frequent cause of death in tetanus is, in fact, rapid or slow asphyxia. Patients with tetanus may die from pulmonary inflammations (Verneuil)—pneumonia or capillary bronchitis—which cause sudden and considerable elevation of temperature. Death may also be the consequence of the general disturbance of nutrition,

and of nervous exhaustion, favored no doubt by the difficulty and sometimes the impossibility of sufficient alimentation; finally, it may also be due to spasm or paralysis of the heart; it seems to occur very seldom without the influence of some complication.

When, on the contrary, *recovery* is going to take place, the beginning of the disease is more insidious and more distant from the date of injury, the trismus continues several days without being complicated with other spasm, and the patient presents neither anxiety nor elevation of temperature; the contraction may, in mild cases, remain limited to a small number of muscles, as we have seen; if generalization does occur, it does not continue a long time; the violence of the contractions diminishes; the muscular groups are gradually relaxed; and soon spasm, which still embarrasses large movements, occurs only at the moment of voluntary contraction, to disappear completely after a period which is sometimes of considerable length. The patient now enters upon convalescence, but he is a long time in recovering, and only slowly regains his strength. This long convalescence demands very careful watching, since relapses are much to be feared, and readily supervene under the influence of cold. We have seen that elevation of temperature may also be observed in benign cases; this disappears at the moment of recovery, but the lowering of temperature is not always a favorable sign, since it has been seen to precede death.

Diagnosis of Tetanus.—The onset of tetanus may sometimes not be recognized, to the great disadvantage of the patient, and the initial trismus may be confounded with a contraction of the elevators of the lower jaw consecutive to an *inflammatory affection* of the alveoli, teeth, or gums, or of the maxillary bones themselves, and the stiffness of the neck which accompanies and occasionally precedes it with a *rheumatic torticollis.* This error may be avoided by remembering that in these cases the efforts which are made to overcome the resistance of the muscles does not determine, as in tetanus, painful spasms with momentary exaggeration of the contraction. The converse error is yet much more easily avoided, except perhaps in cases of *temporo-maxillary arthritis*, which, however, a methodical exploration of the region ought to permit to be recognized. Finally, the possible existence, although rare, of *partial tetaniform cramp* must be borne in mind—a kind of essential, tonic spasm which is especially observed in the territory of the motor branch of the trifacial nerve (*masticatory cramp* of Romberg), and which is distinguished by the long duration and harmlessness of its symptoms.

During its stationary period, the remitting stiffness of the muscles, the painful paroxysmal spasms, and the characteristic aspect of the physiognomy, ordinarily render the diagnosis of tetanus evident. There are, however, certain affections which may, occasionally, lead to confusion. I shall not speak of the secondary traumatic spasms, of Follin, which are only cases of tetanus beginning at the point of injury. In *hydrophobia*, the complete muscular resolution between the paroxysms, the wildness of the eyes, the excitement and terrified expression of the patient, the continual thirst, the aversion for liquids, and the abundant salivation, sufficiently characterize the disease, and if a few of these symptoms may be exceptionally met with in tetanus, and may justify, as we have seen, the name of hydrophobic tetanus, the confusion is, nevertheless, only theoretical, and may be readily avoided, clinically, by study of the course of the disease, and by a careful analysis of the symptoms. The mistake, however, seems to have been made, and, according to Brouardel, we may consider as examples of tetanus the cases of hydrophobia, reported by authors, in which the symptoms have begun within 24 or 48 hours after the bite. Sabatier cites a case of tetanus consecutive to a fracture of the leg,

which was complicated with a true hydrophobia, and, finally, Girard[1] has attempted to demonstrate the identity of the two diseases. The principal elements of diagnosis are the much longer incubation in hydrophobia, varying between three and twelve weeks, and the complete remission of the contraction in the intervals between the hydrophobic paroxysms.

*Spinal meningitis* may be distinguished by the cyclical course of its temperature, and by the different type of its contractions, soon followed by paralysis. It seems equally difficult to admit a possible confusion between the tonic spasms of tetanus and the clonic convulsions of *epilepsy*, which are accompanied by a complete loss of consciousness. The much more rapid course of the symptoms, with intervals of absolute remission if the poison has been taken in several doses, permits the recognition of *poisoning by strychnine.*

The diagnosis of tetanus may be rendered more difficult if it is complicated with *hysterical phenomena*, which more or less distort its usual type; the great variability in the manifestations of hysteria do not permit the laying down of rules for diagnosis upon this subject. It will be the part of the practitioner to endeavor to separate, in each case, that which belongs to each of these two diseases.

The diagnosis of tetanus of the new-born from uræmic brain-disease of tetanic form, has not yet been referred to, but we have seen that the existence of true tetanus is doubtful in these conditions, and we must therefore wait for new observations upon this point.

Finally, ought tetanus to be distinguished from *tetany* (*intermittent tetanus, contraction of the extremities*); or should this, as it is by some authors, be considered one and the same disease with spontaneous tetanus? The mild cases, in which the contraction, being frankly intermittent and brought back by compression of the limb, is limited to the extremities, seem evidently quite distinct. But there are grave cases, where the contraction is generalized, and where the disease may become fatal. Although the mode of onset, the course of the contraction—which goes from the extremities to the trunk—and the possibility of causing it by compression of the limbs (characters indicated by Trousseau), may permit the recognition of tetany, yet the existence of this grave form tends to affirm the physiological relationship, if I may venture so to speak, of these two clinically distinct affections.

Prognosis.—From what has been said above, it results that tetanus is a very grave disease, and that death is always to be feared, even in the forms apparently the most benign; but its prognosis is far from being fatal. It is a little less grave in cases of spontaneous tetanus and traumatic tetanus without wound, and in those which begin a long time after the traumatism. The gravity of the traumatism itself, does not seem to have any influence upon that of tetanus. The cases in which the onset is by trismus, are more grave than those in which pains and centripetal convulsions are observed in the injured limb; at least the latter are much more accessible to active intervention. Finally, much importance has been attached to the duration of the disease; it is true that the slow forms are less grave, but we have seen that death may yet occur at the end of several weeks.

It is important to inquire what may be the influence of treatment upon the termination of tetanus. Must we maintain the absolute distinction into two forms, the one acute, inevitably mortal, and the other chronic, which recovers by itself, and in which the sole part of therapeutics is to prevent death by asphyxia and give the patient ease? I believe it more correct to

[1] Sur la non-existence d'un virus rabique. Lyon, 1827.

say, with Richelot, setting aside the overwhelming (*foudroyant*) forms, which seem beyond the resources of art, that the acute forms have never been directly cured, but that treatment may make chronic some cases of tetanus which have begun as acute, and may stop generalization and death in some cases in which they would occur, if the disease were abandoned to itself.

Treatment of Tetanus.—Without affirming, as does Rose, that tetanus may always be attributed to a mistake made in the treatment, it is evident that its development can but be favored by cold and by unseasonable irritation of wounds, and that the removal of these causes should enter into the *preventive treatment* of tetanus.

A question more grave is that of *preventive amputation*, proposed by some authors when tetanus occurs in successive cases. The majority of surgeons reject the operation when the traumatism itself does not indicate it, but they admit that the existence of an epidemic of tetanus may incline the balance in favor of amputation in doubtful cases. I mention here, in order not to have to recur to them, the *accessory means* employed for special indications: the wedge of wood for separating the teeth—useless, since the space situated between the last molars and the coronoid process of the inferior maxillary bone always permits the passage of an œsophageal tube, which may also be introduced through the nasal fossæ (but it must be remembered that an irritation of the larynx may cause spasm and sudden death); nutritious enemata when alimentation by the mouth is not possible; purgatives from time to time; catheterization in case of retention of urine; and, finally, tracheotomy, which is indicated in case asphyxia through spasm of the glottis constitutes the principal danger.

The innumerable methods which have been extolled as *curative measures* for tetanus may be arranged, as is done by Richelot, in three classes, according as they endeavor to suppress the initial irritation, to modify the state of the nerve-centres, or to directly check the muscular contraction. In the first rank should be placed the *surrounding conditions*, which, according to Renzi, constitute a sufficient treatment. The Italian surgeon places patients with tetanus in an isolated, dark, and well-warmed room, where they remain in silence and the most absolute quietness. Without being as exclusive as he is, it must be acknowledged that these precautions are valuable adjuvants to other means of treatment, and that they should be employed whenever it is possible. In order to maintain around the patients a warm and even temperature, it is important at least to cover them with an eider-down quilt. These precautions will prevent the external excitations which determine most of the paroxysms.

But it is necessary to endeavor to overcome the cause itself of tetanus, the peripheral irritation which has been its point of origin. Such is the object of *local treatment*, the only rational means of arresting the malady at its beginning. The surgeon must inquire if there be not some evident, local cause of irritation, painful granulations which can be cauterized, or a too sensitive cicatrix which should be destroyed with the bistoury or caustics. Apart from these indications, we must confine ourselves to an infrequent but very careful dressing of the wound, and not irritate it with blisters or ether spray. If this simple treatment, in connection with internal medication, which we shall study presently, does not cause a rapid amelioration of the symptoms, it becomes necessary to adopt more active measures, and to choose between amputation, neurotomy, and nerve-elongation or nerve-stretching.

*Amputation* is only admissible when it would be justifiable even without the complication of tetanus; at the present time it is known that an amputa-

tion, during the height of this disease, has not the dangers which might theoretically seem connected with it.

*Neurotomy*, the efficacy of which has been made unquestionable by the instantaneous amelioration and rapid recovery which have followed it in some cases, has the inconvenience of always leaving as a result a more or less complete paralysis, notwithstanding the possible re-establishment of the nervous functions by regeneration, or through collateral channels. It is especially indicated when the spasms begin near the seat of injury, before their generalization; but it may still contribute much to recovery when generalization has occurred, by removing the cause which keeps up the spinal irritation. The choice of the nerve to be cut, is determined by the surgeon's knowledge of anatomy, by the pain upon pressure, and, when this symptom exists, by the course of the tetanic aura, which then constitutes the most precise indication for the operation. The operation should be done as soon as possible, and at a greater distance from the wound as it is more delayed, on account of the possible development of an ascending neuritis. The incision should be small, and should be dressed with care, so as not to create a new cause of irritation. *Polyneurotomy* has the inconvenience of increasing the traumatism, and of leaving as a result a too great infirmity. I shall refer to this point again in connection with the operations which are practised upon nerves.

Together with neurotomy are to be considered the crushing and elongation of nerves, which are indicated by the same conditions. The *crushing* of nerves acts also in interrupting the nervous current; it has, perhaps, the inconvenience of being less certain, but the persistence of the neurilemma renders more constant and more rapid the regeneration of the nerve-trunks.

Finally, the operation of *elongation* or *stretching*, which only momentarily interrupts the conductibility of the nerves, has the great advantage of not leaving after it persistent paralysis; this more easily permits the surgeon, in the absence of precise indications, to operate upon several nerves of a limb, or even upon all, which certain writers have laid down as a rule. Already several cases of nerve-elongation in tetanus, followed by recovery, have been reported. If its efficacy were demonstrated, it would be preferable to both division and crushing of nerves.

The *internal medication* intended to modify the condition of the nerve-centres should always be associated with the local treatment. Considering spinal congestion as the cause of the symptoms, antiphlogistic, contra-stimulating, and alterative remedies have been recommended, with the application of revulsives along the spine. Labbée refers to a patient of Lisfranc's, who recovered after 19 bleedings and the application of 772 leeches. This method may be of service, employed in more moderate measure, in some cases. Among remedies which have been especially resorted to in tetanus must be mentioned chloral and opium.

*Chloral*, though indicated by its physiological properties and its special action upon the reflex function of the spinal cord, has never arrested the disease, as has neurotomy, for example, and does not prevent its offensive recurrences; but it quiets the spasms in an unquestionable manner, and, if it has often failed, perhaps because local treatment and the maintenance of good surrounding conditions have been neglected, nothing proves that some cases of tetanus which have remained local with chloral would not have become generalized without it. In every case it is a very useful adjuvant, which gives the patient comfort, and permits the disease to run its course without mortal accident. Nevertheless, it does not always prevent death from occurring by nervous exhaustion, notwithstanding the localization of the spasms; perhaps even some deaths which have taken place in collapse may have been due to its use in too large quantities. It may be administered by

the mouth or by the rectum, or may be introduced directly into the veins. Administration by the mouth should be preferred, as long as it is possible and sufficient, and we should always begin in this way. Chloral should be given by grammes until muscular relaxation and sleep are obtained, and its action should be kept up with care for quite a long time, only permitting the patient to awake in order to take food. The time during which this mode of treatment should be employed, is a matter for experiment, varying in each case. It may be said, however, that chloral has been administered more than a month without producing *gastro-enteritis.* There are some patients, however, in whom this medicine determines vomiting; then, as when dysphagia is very marked, it is necessary to give the drug by the rectum in the same doses. It is only when administration by the mouth or rectum is not borne, or when the effect is not sufficient notwithstanding the use of quite large doses, that another plan may be resorted to—intra-venous injection—chloral being too caustic to be employed with advantage hypodermically. Particularly extolled by Oré, of Bordeaux, intra-venous injections of chloral are advised by surgeons of authority. The action of chloral used in this way is more rapid and more durable than when employed otherwise. It has been objected to this method, that it exposes to accidents, and especially to the formation of clots, but these may be avoided by being very careful in performing the operation. Oré advises the employment of a very slender trocar and a syringe with well-graduated piston, provided with a fine strainer, in order to arrest little foreign bodies; the vein must be opened by a direct puncture, after having been made prominent by a circular ligature placed around the limb; the trocar is next withdrawn; the syringe is adjusted to the canula, after a few drops of blood have flowed; and a solution containing 9 grammes (gr. cxl) of chloral in 10 grammes (f℥iis) of water, with a few drops of a ten-per-cent. solution of carbonate of sodium is slowly thrown into the vein. Eight grammes (f℥ij) of the solution may be injected each time, if there is no accident, and one or two injections at most are given in the 24 hours. An induction battery should be at hand, in case of syncope.

*Opium*, *morphia*, and *laudanum* begin by congesting the spinal cord, and have no effect against tetanus except in very large doses, at the price of serious digestive disturbances. Therefore, according to some authors, they should be absolutely banished from the therapeutics of tetanus; others, on the contrary, recommend them when chloral does not succeed. There are, further, extolled as remedies against tetanus, with the object of modifying the nerve centres, a host of medicines, of which I shall only name the chief: *Belladonna* and *atropia*, which lessen congestion of the nerve-centres, and may serve as adjuvants to a more active method; *Ergot*, which indeed acts upon the vessels of the spinal cord, but may determine gangrene; *Calabar bean* and its alkaloid *eserina*—1 to 4 milligrammes (gr. $\frac{1}{64}$ to $\frac{1}{16}$) by subcutaneous injection—which causes a temporary relaxation, perhaps by acting directly upon the muscles; *Bromide of potassium*, which, in order to act, must be employed in dangerous doses; *Chloroform* and *ether*, by inhalation, which may cause death during the period of excitement, and which necessitate, on the part of the physician, continual attention, rendering their employment not practical—it is the same with *nitrite of amyl*, the effects of which are yet incompletely known; the *continued currents*, which have only a temporary action, and upon the employment of which there is, moreover, a difference of opinion, Le Fort and Verneuil recommending ascending currents, and Legros and Onimus, and Dubrueil, on the contrary, descending currents. There have been extolled, moreover, hemlock, tobacco, nicotine, aconite, salicylic acid, cannabis indica, alcohol in large doses, etc. I may further mention *diaphoretics*, which constitute a good complement of treatment, and particularly steam baths, provided

that they can be given in bed without too much disturbing the patient. *Tepid baths* seem more rational than cold baths and cold douches, from which good effects have, however, sometimes been obtained; both have the inconvenience of necessitating movements which are very painful and very unpleasant. Finally, it can be understood that the *sulphate of quinine* has been employed with success against the malarial forms.

I shall say but one word as to the treatment which aims only to directly stop the muscular contractions: it is a symptomatic medication, necessarily insufficient, and temporary in action. Thus act acupuncture, the different liniments which have been devised for the treatment of tetanus, the sulpho-cyanide of potassium, and curara. In regard to the latter medicine, I may notice an interesting case by Hoffmann,[1] in which the curara was administered by intra-venous injections, eight in number, each containing 17 milligrammes (gr. $\frac{1}{4}$ +) of the medicine. This case is not favorable for the treatment with curara, since the patient died from arrest of the heart's action for which, perhaps, it was responsible; but the case is singular in the fact that, at the autopsy, there was found no vascular or circulatory lesion, notwithstanding the eight injections given in a few hours, which proves the harmlessness of intra-venous injections made with care.

*Conclusion.*—To summarize: in the presence of a case of tetanus it is necessary to put the patient in the most favorable surroundings, and at once to administer chloral until resolution of the spasms is obtained; at the same time local treatment must be resorted to, that is to say, any cause of irritation which may exist in the wound must be removed, and if none can be found, or if this first interference is not sufficient, amputation, neurotomy, or nerve-elongation must be immediately decided upon. To this fundamental treatment may be joined some accessory means, such, for example, as the use of diaphoretics and belladonna.

Thanks to this rational treatment, without hoping yet to triumph over the hyperacute forms, a certain number of acute and chronic cases of tetanus may be arrested and cured.

## Operations which are Practised upon Nerves.

Several operations are practised upon nerves. These are *nerve-suture*, *nerve-elongation* or *nerve-stretching*, simple division or *neurotomy*, and resection or *neurectomy*.

It sometimes occurs that the nerves which are in the neighborhood of bones are found, after a fracture for example, inclosed in an osseous canal. This has been observed in the case of the radial [musculo-spiral] nerve at the surface of the humerus. In these cases an operation is performed to *dislodge the nerve* with chisel and mallet.

The same operation has been done to *isolate the nerve* from the lardaceous, fibrous tissue which sometimes surrounds and ensheaths it as a result of chronic inflammation. The older surgeons practised *cauterization of nerves*, in cases of neuralgia, but this operation is at the present day abandoned.

### I. Suture of Nerves.

History.—We may divide the history of the suture of nerves into three periods. The first, from the date of Hippocrates and Galen to 1776, the time

[1] Berlin. klinische Wochenschrift, No. 43, 1879.

when Cruikshank established the reality of the cicatrization of nerves; the second, from 1776 to 1864, the epoch of the publication of the work of Weir Mitchell upon Gunshot Injuries of Nerves, after the war in the United States; the third, finally, from 1864 to the present time (Poinsot).

During the first period, the possibility of the cicatrization of nerves was denied by some (Hippocrates and Galen) and admitted by others, some of whom (Guillaume de Salicet, Lanfranc, Guy de Chauliac, etc.) even recommended the suturing of these organs. Unfortunately, the confusion which then existed between nerves and tendons does not authorize us to dwell upon the opinions of these authors. At all events, this practice was very little in favor, since Ambroise Paré does not even speak of it. After the labors of Cruikshank, Fontana showed the nervous nature of the cicatrix of nerves, and recommended their suture, which was also subsequently advised by Dupuytren, who, however, admitted the possibility of the cut nerve being substituted by the anastomoses to which Horteloup attributed, even exclusively, the re-establishment of the functions of the peripheral end.

Finally, the clinical period opened with the work of Weir Mitchell and the observations of Nélaton, Laugier, and Richet, at the same time that the apparent contradictions between the clinical and experimental results were explained by the investigations of Messrs. Arloing and Tripier on "sensory-motor substitution." We shall first study the indications and operative manual of nerve-suture, and afterwards we shall see the results furnished by this operation in the small number of cases that have been published, and we shall inquire what conclusions can be drawn regarding its utility in respect to the re-establishment of nerve-function.

Indications.—Although, according to some authors (Vulpian, Tillaux, Magnien, Dubrueil, Poinsot) every complete division of a nerve is amenable to the suture, agreement upon this matter is far from being unanimous, and from this point of view it becomes important to divide complete sections of nerves into three categories, according to whether they are simple, complicated with more or less considerable destruction of the neighboring parts, or accompanied with crushing or laceration of the cut extremities.

When the section is clean-cut and simple, without extensive wound of the integument, the suture should not be resorted to unless the separation is considerable; but it may be required when there are found extensive lesions of the skin and neighboring parts, so that position alone is not sufficient to cause the extremities of the nerve to come together (Jamain and Terrier, Tripier). The indication for suture is still more urgent if the nerve has experienced a loss of substance. When the section of the nerve is accompanied with crushing, most authors agree in advising suture after resection of the contused part, except Tripier, according to whom this practice increases, without any benefit, the causes of inflammation of the nerve and soft parts. Finally, reference must be made to the opinion of Follin, who positively rejects the suture of nerves.

This operation should naturally be done as soon as possible after the accident. It is important to perform it before the appearance of suppuration. It may, however, still be practised in order to reconstruct a nerve, the extremities of which have separately cicatrized (Tillaux, Letiévant); it is then necessary to make a more or less extended resection of the nerve extremities, or to employ one of the procedures of nervous autoplasty, described by Letiévant, which will be mentioned in connection with the mode of operating.

Operative Manual.—The operation of nerve-suture includes four stages: (1) Searching for the ends of the cut nerve; (2) Their examination and

freshening, if this is necessary; (3) Passing the threads; and (4) Their adjustment.

(1) The *search for the two ends* of the cut nerve is generally easy, since these structures present but little contractility; nevertheless it demands accurate anatomical knowledge. If the wound is narrow and deep, it will be of great advantage to enlarge it by an incision, parallel to the course of the nerve, in order to spare as much as possible the manipulation of the wound, which prevents immediate union, and also in order to facilitate the passing of the threads. For this first stage of the operation, Esmarch's bandage will render service; if it be feared that the rubber band, applied from the extremity upwards, may increase the separation of the nerve-extremities by pushing back the upper end to a higher point, it will be then preferable to employ only the band with rings (Figs. 364, 365, page 77), which I long since proposed to take the place of the tube. The two extremities of the nerve are found without great difficulty; it may happen, however, especially when there are extended lesions of the neighboring structures, or when the nerve has undergone a loss of substance, that it may be impossible to find the central end; in this case, *two different nerves may be united together* (Flourens). If several nerves have been divided, the lower end of the most important nerve must be united to the upper end of another; for example, the lower end of the median nerve to the upper end of the musculo-cutaneous nerve; if the musculo-cutaneous be not divided, the *grafting* of the lower end of the median to the musculo-cutaneous nerve may be attempted, after freshening a small surface of the latter (Letiévant).

(2) The two ends of the nerve being found, if the section is clean-cut and recent, it only remains to pass the threads; if, on the contrary, the extremities of the nerve are crushed, or if they have become separately cicatrized, most authors agree in advising to *resect a portion of variable extent*, and then to apply the suture, as if the case were one of recent wound.

(3) We now come to the most delicate stage of nerve suture—to the *passing of the threads* destined to connect the two extremities of the divided nerve-trunk. We shall successively examine the kind of needle and of thread which should be employed, the number of threads to be used, and the point at which they are to be passed. Generally, for this operation, ordinary, fine suture-needles are employed. Wolberg, of Warsaw, has proposed for this purpose a special needle; he has given it the shape of a curved sword, very thin and lance-shaped in the direction of its length, and with an oval eye, large enough to receive the thickest catgut. This author has examined with the microscope nerves sutured with this needle, and has found that the nerve-fibres have been notably less damaged than when an ordinary needle has been used. All kinds of thread have been employed. Gen recommends catgut; H. Page, catgut or silk; Richet, silk; Vulpian, linen-thread; Jamain and Terrier, silk or silver wire; Letiévant and Nélaton, silver wire. To sum up, the choice should lie between catgut, Chinese silk, and Florence thread.

As to the number of points of suture and the part of the nerve-trunk which they should traverse, agreement is equally wanting. Weir Mitchell, in his experiments upon animals, obtained sufficient approximation by passing one or two threads into the neighboring tissues adherent to the sheath of the nerve; Richet advises placing two threads involving only the neurilemma; Wlalowski also is of the opinion that the neurilemma only should be included in the loop of thread, claiming that the consecutive paralysis is more marked when the nerve substance is involved; finally, others pass the thread through the nerve-substance itself (Nélaton, Wolberg, Vulpian, Tillaux, Letiévant, Laugier). Among these, some traverse the nerve through and through, the

upper end from before backwards, and the lower end from behind forwards (Letiévant); others do not completely traverse the nerve-trunk, and make the thread come out, either at the lower (Nélaton) or at the middle part of the surface of section (Vulpian). Almost all advise that the threads should enter and come out very near the place of section, in order to obtain a more exact adjustment, and to avoid angular deviation of the two ends. One thread only is usually employed; two should not be used unless the nerve be very large.

(4) The adjustment also should be as exact as possible. It is effected, according to the kind of thread used, either by making a double knot, or by twisting the thread with forceps; or the surgeon may do as Nélaton did, in order to facilitate the removal of the threads—pass them into a Galli's tube, at the extremity of which they are bent upon themselves; whatever may be the procedure employed, the tension used must be moderate. If the division of the nerve be accompanied by division of the tendons, Tripier recommends, when the threads have been passed, that they should not be tightened until after the completion of the suture of the tendons.

The extremities of the nerve once in contact, it remains only to suture the wound of the integument; the threads which unite the ends of the nerve are brought out at one of the angles of the wound, and are fastened with adhesive plaster, as recommended by Letiévant, if silver wire has been used. The essential condition of the dressing is to avoid suppuration, and to obtain union by the first intention, at least in the deep part of the wound. It is best then to follow, during the whole operation, the rules of the antiseptic method, and to apply over the wound a Lister dressing after having provided means of drainage, if necessary. Besides these precautions, it is required, in order that union by the first intention should have any chance of success, that the operation should be done before the establishment of suppuration, and that, as we have said above, too prolonged manipulation of the wound should be avoided, and especially bruising of its edges and injuring of the tissues which surround the nerve, in the process of searching for the two ends. To finish the dressing, the limb must, in addition, be immovably fixed in such a position that the threads shall not be pulled upon; and this precaution is particularly important when the nerve has undergone a loss of substance. The best means to maintain the limb in a favorable position is to apply a plaster splint immediately after the operation. When silver wire has been employed for the nerve-suture, the wire must be removed at the end of fifteen days. Gen, in fact, has observed that union is generally complete on the twelfth day; it is true that his experiments were made upon animals.

It is difficult to say what is the maximum of separation of the extremities of nerves which permits the suture. Nélaton was able to use it even after having resected a length of six centimetres ($2\frac{1}{3}$ inches) of the nerve-trunk. If the separation is very great, the operation of *nerve-autoplasty with flaps*, proposed by Letiévant, may be employed. This author advises in these cases to make with a bistoury, in the upper end of the nerve, a button-hole slit, beginning five millimetres ($\frac{1}{5}$ inch) from its extremity, and going three or four centimetres (1 to $1\frac{1}{2}$ inches) above; at the upper part of the slit, in drawing out the bistoury, one of the lips is divided transversely, thus forming a flap which is turned back in the direction of the lower end; the same operation is performed upon the lower extremity of the nerve, the flap from which is joined by its freshened surface to the freshened surface of the former, and kept in this position by a point of suture. The results obtained by the author himself are, however, not very encouraging, since in the two cases which he cites he obtained no appreciable result.

Finally, the experiments of Gluck, of Berlin, in *neuroplasty by transplantation of nerves*, must be referred to. This author has resected in chickens

three or four centimetres (1 to $1\frac{1}{2}$ inches) of the sciatic nerve, which he has replaced by a piece of the sciatic nerve from a rabbit, sutured at both of its extremities. The chickens thus operated upon walked as well as those upon which direct suture of the sciatic had been practised, while section of the sciatic without suture or autoplasty produced a paralysis of this nerve which was still complete at the end of ten weeks. This procedure is yet in the domain of physiology. When the separation of the ends of the nerve is considerable, and they cannot be brought in contact, the *tubular suture* of Gluck and Vaulair may be tried. The aim of this is to prevent the obliteration of the space which separates the two segments by the interposition of a Neuber's osseine tube. Gluck has only obtained negative results, but Vaulair has seen, he says, after a delay of four months, the regeneration of a nerve-trunk measuring five centimetres (2 inches). He has determined that the regeneration is effected by *centrifugal granulations* arising from the central end, as has likewise been shown by the labors of Eichhorst, Ranvier, and Hahn. He adds that a small portion only of the new fibres unite with the degenerated fibres of the peripheral end.

Results.—The suture of nerves favors cicatrization and hastens the process of regeneration of the peripheral end, but it does not prevent degeneration from beginning; in a word, immediate union of a nerve is impossible, even with the suture.[1] Cases of rapid regeneration, in eight or fifteen days, have been observed only in very young animals, and never in man (Letiévant). Such is to-day the opinion of the great majority of authors, and we need not recall here all the objections that have been made to the alleged examples of immediate union of nerves, which have been set forth in connection with wounds of nerves. The immediate union of nerves without degeneration of the peripheral end is, however, defended by some modern authors, among whom may be named Schiff, Gluck of Berlin, Wolberg of Warsaw, Batowetzki, and Paget.

This operation was at first accused, especially theoretically, of predisposing to *tetanus* and to *inflammatory complications* of the wound, but experience seems to have proved the complete harmlessness of nerve-suture. Eulenberg and Landois have, however, observed, after experimental suture of nerves, intense *neuritis* with deep *suppuration*, and even *purulent infection*. The value of these results is much impaired by the fact that these experimenters operated upon rabbits, animals in which suppuration occurs with the greatest ease. The fact should, however, be taken into consideration, since, as Tripier has well remarked, it might perhaps be the same with man in certain conditions.

Clinical Observations.—The cases of nerve-suture which I have collected from authors, number eleven, and belong to Nélaton, Laugier, Hulke, Richet, Verneuil, Letiévant, Kraussold (two), Busch (two), and Herbert Page. Among these eleven cases, two only are given as unsuccessful; they are the two cases of Letiévant, which relate to complicated cases in which nerve-autoplasty with flaps was resorted to; but in examining the other nine, it is seen that four only can be considered as certain successes; they are those of Hulke, Richet, Kraussold, and Verneuil. That of the last surgeon is particularly interesting, and constitutes an actual experiment; in fact, the median and ulnar nerves were divided, and the median, which alone was sutured,

[1] At least the immediate union of the nerve fibres among themselves; but as regards the immediate union of the ends of the nerve by means of the peripheral and interstitial connective-tissue, this is possible, and should, I think, be sought for.

recovered its functions much more rapidly than the ulnar. In the other cases, the effect of the suture cannot be decided; some of the reports are absolutely wanting in details, and the others date the improvement from a period much too near the time of inserting the suture (from the second, from the fourth, and from the seventh day). The most important fact in all these cases is the complete absence of every kind of complication, even in the two cases of Letiévant. This permits us to believe, notwithstanding the small number of known cases, that the gravity of this operation has been much exaggerated.

[Additional cases of nerve-suture, mostly successful, have been recorded by various surgeons, including Braun, Langenbeck, Esmarch, Ogston, MacCormac, Holmes, Wheelhouse, Holden, Savory, Parks, and F. L. Parker.]

Conclusion.—To summarize, the operation of nerve-suture seems to be indicated in all sections of nerves, though, in certain cases, position alone is, perhaps, sufficient to keep the divided ends in contact. The suture appears to favor and to hasten the process of cicatrization and regeneration of the nerve-trunks; and the few cases which we possess permit us to believe that it does not expose the patient to accidents. There are cases reported of division of nerves, with or without loss of substance, which have not caused paralysis. Paulet has collected them in a memoir,[1] without being able to give any satisfactory explanation of them, and other cases have been recorded since; but these cases prove nothing contrary to the regeneration of nerve-tissue—they only show that this regeneration is not the only mechanism by which the function can be restored. Moreover, their rarity makes these cases a clinical curiosity; the absence of re-establishment of the functions of a nerve, when its extremities have become separately cicatrized, remains the rule, and it is the duty of the surgeon, in dealing with a divided nerve, to insure, by every possible means, the approximation of the two ends, since this affords the least deceptive pledge of functional restoration.

## II. Elongation or Stretching of Nerves.

History.—Elongation of nerves was first studied from a purely speculative point of view by a certain number of physiologists and anatomists, among whom may be named Harless and Haber in 1858, Valentin in 1864, and Weir Mitchell in 1872, but it is since elongation has entered into therapeutics, that have been made the more numerous and more accurate experiments of Schleich, Tutschek, Conrad, Vogt, Trombetta, and Brown-Séquard.

In 1860, during a resection of the elbow performed by Nussbaum, the hook held by an assistant very forcibly stretched the ulnar nerve, and the tetanic cramps which had existed in the arm disappeared after the operation, a result which was attributed by this surgeon to the accidental elongation. This idea was confirmed in Nussbaum's mind by a case under the care of Billroth, who, attending in 1869 a patient attacked with epileptiform paroxysms following a violent contusion of the buttock, believed that the nerve was irritated by a splinter of bone, and denuded the nerve without finding anything. The stretching which the nerve had undergone during the operation was sufficient, however, to cause recovery. Accordingly, in 1872, Nussbaum decided to practise the first intentional elongation, for a contraction of the upper extremity consecutive to a contusion; the contraction yielded to the operation. Gartner and Vogt imitated his practice the same year, and the operation was soon introduced into England by Callender, and

[1] Paulet, Société de Chirurgie, 1868; M. Sée, Société de Chirurgie, 1881.

into France by Verneuil and Blum. At first directed only against neuralgias or cicatricial compressions of nerves, elongation was soon applied to general or partial convulsive affections by Crédé, Baum, Verneuil, Gen, Pooley, and others. Langenbuch, Esmarch, Erlenmeyer, and Debove employed it in locomotor ataxia, and finally, Lawrie, Professor of Surgery at Lahore, applied it in the treatment of anæsthetic leprosy.

Pathological Anatomy.—If elongation of small-sized nerves is made without care, it may determine rupture of the nerve-trunks or avulsion of their roots. But this is an accident of nerve-elongation which exact investigation of the degree of resistance of different nerves will render it easy to avoid. In elongation practised within the limits which will be hereafter indicated, the nerve itself most often does not present any lesion appreciable to the naked eye; the only macroscopic lesions consist in a laceration of the sheath, which gives rise to an audible crackling, and in a rupture of the vessels which are distributed in its interior. These lesions will be more widely distributed if during the operation the limb is not kept extended; flexion, indeed, permits the nerve to be drawn much further from its place.

According to the experiments of Tutschek, the vascular lesions are more marked at certain points which correspond generally to the passage of the nerve into an orifice, or across a fibrous partition.

Authors are not agreed as to the *histological lesions* consecutive to nerve-elongation. According to Valentin, most frequently nothing abnormal is found; according to Schleich, the modifications undergone by the nerve consist in a more or less extended coagulation of the myelin; Tarchanoff has observed, immediately after the elongation, traces of hyperæmia and capillary hemorrhages, and the division, in a certain number of nerve-fibres, of the myelin and axis-cylinders, the sheath of Schwann remaining always intact; finally, Scheving, examining elongated nerves after a certain time, found healthy fibres, especially at the centre of the nerve; fibres in a state of secondary degeneration, above and below the point of elongation; and some fibres in process of regeneration. In fine, elongation seems to cause most frequently the rupture of a certain number of nerve fasciculi. Forcible elongation of large nerve-trunks affects even the spinal cord.

By carrying the elongation further, avulsion of the nerve is produced, either at a point where it is reflected upon itself, or at its root. It may be added that Blum has proposed avulsion as a mode of treating obstinate neuralgia of the superior maxillary nerve. If simple elongation is replaced by *elongation with crushing of the nerve* on the groove of a director, as is done by Verneuil, or between forceps, there will be evidently observed a grinding and more or less complete division of the nerve-trunk, thus producing a kind of sub-neurilemmatous neurotomy.

Physiology.—The physiology of the elongation of nerves includes an inquiry into the resistance and extensibility of the nerve-trunks, and a study of the effect of elongation upon their functions.

The principal experiments upon the *resistance of nerves to traction* are those of Tillaux and Trombetta. The results obtained by these two authors are quite different. Thus, Tillaux caused rupture of the sciatic nerve with a mean force of 58 kilogrammes (128 lbs. Av.),[1] while Trombetta had to employ a force of 84 kilogrammes (185 lbs. Av.); but the great difference in the processes used, must be taken into account. Tillaux, who made his ex-

[1] Symington Johnson caused rupture of this nerve with a mean weight of 59 kilogrammes (130 lbs. Av.). Lancet, 1878, vol. i. p. 904.

periments before the discovery of elongation, and from a purely anatomical point of view, drew upon the nerve in the axis of the limb, after having divided circularly the other soft parts and the bone, at the point at which he wished to apply the traction. Trombetta, on the contrary, whose experiments are recent (1881), made them resemble, as closely as possible, the operation of elongation as practised upon the living subject; this gives special interest to his results, of which I reproduce the most important:—

| | Kilos. | | Kilos. | | Kilos. |
|---|---|---|---|---|---|
| Supra-orbital branch, | 2.720 | Seventh cervical branch | 23.416 | Radial nerve, | 27.750 |
| Infra-orbital branch, | 5.477 | Eighth cervical branch and first dorsal, | 29.460 | Ulnar nerve, | 26.500 |
| Mental branch, | 2.492 | | | Femoral nerve, | 38 |
| Fifth cervical branch, | 22.820 | Brachial plexus in axilla, | 17 to 37 | Sciatic nerve, | 84 |
| Sixth cervical branch, | 24.134 | Median nerve, | 38.18 | Popliteal nerve, | 52 |

The results obtained by Gillette for the sciatic nerve agree with the preceding: in 45 elongations practised upon 23 cadavers, at Bicêtre, this surgeon 12 times obtained avulsion of the nerve with a force of from 200 to 75 kilogrammes; 29 times, rupture with from 165 to 42 kilogrammes, not including one instance in which a softened nerve yielded to a traction of two kilogrammes, but in which the softening was evident upon simple inspection; finally, in three cases, tractions of 45, 90, and 200 kilogrammes, caused neither avulsion nor laceration of the nerve.

From these results, it is seen that rupture during elongation is not to be feared as long as the nerve is a moderately large one, since Blum has demonstrated that it is impossible to employ a force of more than 15 kilogrammes (33 lbs. Av.) in making extension with a grooved director. Gillette recommends a force not exceeding 20 kilogrammes (44 lbs.) An attempt has also been made to ascertain what *lengthening* the nerves may undergo under the influence of traction. The conclusions from the experiments of Vogt upon this subject are, that the nerves of man are but little extensible, and that their extensibility diminishes from the centre to the periphery; according to this author, the extensibility of the nerves is exhausted in certain forced movements; for example, in flexion of the thigh upon the pelvis while the leg is extended. This fact, which has been verified by both myself and Trombetta, has led the latter to propose a new method for the elongation of nerves.

Let us now see what are the *physiological changes* determined by this operation. And first, what elongation of the nerve is necessary in order that these changes shall be produced. Weir Mitchell made experiments upon rabbits, and found that slow elongation, limited to the sixth of the primary length of the nerve, did not change its electric excitability. This excitability disappeared much sooner if the elongation was sudden. He adds, that very probably a much less powerful elongation would suffice to withdraw the muscles from the influence of the will, and to hinder the transmission of slight sensory impressions. The extensibility of nerves, however, varies too much in different animals, for the results obtained in one to be applicable to another.

We shall successively consider the changes determined by elongation in the excitability, the sensibility, and the motility of the nerves, and its influence upon the spinal cord and nerve-centres. All experimenters have recognized that direct and reflex *excitability* of nerves disappears under the influence of strong traction; the majority have, moreover, remarked that this excitability increases if the force used does not exceed a certain limit, fixed by Tarchanoff at half of the force necessary to cause rupture of the nerve, which seems a little exaggerated. Finally, according to Conrad and Scheving, the sensory fibres lose their excitability before the motor fibres — a very interesting

result, to which we shall have occasion to revert, and which may furnish us an important guide in the practice of elongation.

*Sensibility* is increased at the beginning of traction, disappearing more or less completely, and more or less permanently, according to the force employed and the duration of the time of traction, at least in healthy subjects; traumatic palsies have been known to be cured by elongation (Blum, Nussbaum's first case), and Brown-Séquard has demonstrated the more or less rapid return of sensation, frequently with hyperæsthesia, in a limb rendered anæsthetic by semi-section of the spinal cord. Lastly, elongation, practised by Lawrie upon patients attacked with anæsthetic leprosy, caused, in a great number of cases, at least a temporary amelioration, even when the traction had accidentally produced rupture of the nerve.

*Motility* is less easily influenced by elongation. According to Blum it may be re-established by a slight elongation in some cases of traumatic paralysis. It disappears more or less completely, but always in a temporary manner, when the elongation is violent. Lastly, when the elongation is moderate, although sufficing to produce anæsthesia, only temporary paresis is usually observed. According to Scheving, the paresis is slight, or altogether absent, if the elongation is applied to the central end, while the traction exerted upon the peripheral end determines motor paralysis without anæsthesia. Finally, Valentin has ascertained that the electro-motor quality of the myelin is modified by powerful mechanical actions.

The effects of elongation are not limited to the territory of the elongated nerve; they are also felt, as several observers have recognized, in the nerve of the opposite side. Brown-Séquard, after having rendered animals hemi-anæsthetic by section of half of the spinal cord, saw sensibility return, after elongation of the sciatic nerve, even in parts not supplied by that nerve. Finally, Marcus and Wiet have produced glycosuria in the rabbit by elongating the central end of the pneumogastric, and even of the sciatic nerve. These facts seem to demonstrate, in spite of the contrary opinion of Vogt, that the effects of elongation make themselves felt even upon the spinal cord and nerve-centres. Gillette, moreover, has been able to directly determine upon the cadaver that tractions exerted upon the sciatic nerve communicate a notable shock to the spinal cord.

It seems equally probable that centripetal elongation of a nerve is propagated to its branches, and may act through them upon the terminal nerve structures. It may be added that, in the majority of experiments, the appearance of quite marked *trophic disturbances* has been noted as a result of the elongation of mixed nerves, but that these disturbances have not been observed after elongations practised upon man, at least to a degree sufficient to constitute a contraindication. Elongation may, however, be followed immediately or quickly by serious accidents, when it is practised upon the cranial nerves, and particularly upon the branches of the Gasserian ganglion. Although several surgeons have been able to perform, without any ill result, elongations of the cranial nerves, notably the branches of the trifacial, it may be feared that this will not always be so. At the Surgical Society of Paris, Tillaux and myself have called attention to the loss of the eye which sometimes follows resection of the superior maxillary bone, and which results from the avulsion of the incompletely divided infra-orbital nerve.

In cases of painless spasm of the muscles of the face, elongation of the facial nerve might be followed, as has actually happened, by more or less lasting, or even permanent paralysis. In these cases I should prefer sub-neurilemmatous neurotomy, or crushing of the nerve. I think then that a distinction should be established between the elongation of spinal nerves and that of cranial nerves, and that the latter should be done only with reserve and pru-

dence, in the fear of immediately fatal reflex effects, or of trophic disturbances, as in avulsion of the branches of the trifacial.

It is evident that the mode of action of nerve-elongation will be differently understood, according as one or the other of the preceding views is adopted, and will be explained by a change in the nerve itself or in the terminal nerve-structures, but the majority of authors agree in recognizing that it most often acts by diminishing the conductibility of the nerve, and not by freeing it from adhesions or pathological sources of compression, as was at first believed.

By what mechanism is the *diminution of conductibility* produced? Is it due to compression of the medullary substance, to a modification of the electromotor power of the nerve, and to a separation of the myelin and of its sheath (Valentin); to suppression of the elastic pressure of the sheath upon the nerve, or to disturbances of nutrition by vascular lacerations (Harless, Vogt); or must it be explained by an incomplete rupture, as it is by Verneuil, who has, substituted crushing for elongation? The diminution of conductibility being admitted, the therapeutic action of elongation may, with Callender, be explained by a kind of *isolation of the nerve centres*, which permits them to resume their normal action, previously disturbed by peripheral irritation.

As to the direct influence of elongation upon the nerve centres, it appears to have been demonstrated by the physiological experiments which have been above referred to, but its nature is still unknown.

Finally, in certain cases, it may be believed that elongation has acted as any traumatism. This opinion is sustained by a case reported by M. Berger to the Society of Surgery, in March, 1882—a case in which the opening of an abscess beneath the quadriceps femoris muscle caused the disappearance of the lightning pains of ataxia.

To summarize: elongation acts at the same time upon the nerve centres and upon the nerve trunks submitted to traction, most frequently by diminishing their sensory conductibility, probably by the mechanism of an incomplete rupture; but it must be clearly recognized that this explanation does not account for all the facts, and notably for those where a pathological or experimental anæsthesia has disappeared under the influence of treatment. The minute study of new clinical and experimental facts, and the endeavor to determine the exact force employed in each case, will, no doubt, point the way to the true explanation of these phenomena.

Clinical Results.—We have seen that, as regards the function of the nerve, elongation, when well performed, has but little influence over motility, and is never followed by persistent paralysis of movement, while, on the contrary, the appearance of a lasting anæsthesia is indispensable to its therapeutic action, when it is directed, as is most frequently the case, against an exaggeration of the direct or reflex sensory-motor irritability of the nerves. We must now inquire what has been the action of this therapeutic agent upon the several affections for which it has been employed.

The great majority of elongations have been practised in cases of *neuralgia*, and particularly of *sciatic neuralgia*, and often the disappearance of the pain has been obtained; unfortunately, the proportion of definitive recoveries cannot be exactly known, because most of the cases are published too short a time after the operation. Thus, Walsham, studying forty-eight cases of neuralgia, reported as cured by elongation,[1] showed that nearly all had been published too soon. In fourteen of the cases, which he was able to trace, there were nine definitive recoveries and five relapses, following after intervals of from

[1] British Med. Journal, December, 1880.

five to eighteen months. Indeed, *traumatic neuralgias* are those which furnish the greatest number of successes.

*Spasmodic affections* of traumatic origin have also been treated by this procedure. It is known that the first intentional elongation was done by Nussbaum for a contracture consecutive to a contusion of the arm, and that his patient was cured, recovering even the lost sensibility of the dorsal skin of the forearm. In *tetanus*, elongation has given several successes, attributed to Vogt, Verneuil, Clark, Ratton (of Madras), and others, when the operation has not been done too late, and when all the nerves coming from the diseased region have been elongated. Recovery has also been obtained in some cases of *reflex epilepsy*, with well-marked aura. We have seen that, in Nussbaum's case, the sensibility returned as a result of the elongation. Blum has also obtained a recovery by employing this operation in a case of *traumatic paralysis* of sensation and motion in the forearm. This surgeon explains the result by the feebleness of the traction, which increases the conductibility of the nerves; but Laurie, of Lahore, and Bomfort, obtained analogous results in patients attacked with anæsthetic leprosy, by making very strong traction, and in some cases in spite of rupture of the nerves during the operation. These patients were not under observation long enough after the operation for it to be known if their recovery was definitive.

Elongation has also been proposed by Wecker[1] for certain affections of the *optic nerve*, but this author has as yet only performed it upon patients who were irrevocably blind, so as to study its influence upon pain, hallucinations, etc.; the operation did not have any annoying result. Elongation of the optic nerve has also been practised by Pamard, of Avignon.[2]

Certain *affections of the spinal cord* are also amenable to elongation. It has been recently quite often performed, especially in Germany, for the relief of the shooting pains of locomotor ataxia, and this operation, which has been practised upon the sciatic nerve in most of the cases, often makes the pain disappear, and ameliorates for a longer or shorter time the motor incoördination; this amelioration was maintained to the end, in a case of Langenbuch's, the patient dying three months after the operation in an attack of epilepsy. In a case of probable cancer of the spinal cord, successive elongation of both sciatic nerves caused a cessation of the intolerable pains, the first time for fifteen days, and the second time for five days.[3] Nussbaum cured, by elongating the femoral and sciatic nerves, a patient who had suffered for eleven years from paraplegia with contracture, which had followed a fall upon the sacrum. Finally, elongation has been unsuccessfully tried for the cure of the lesions consecutive to infantile paralysis, and for those following cerebral hemorrhage.

In brief, the principal indication for elongation is the exaggeration of the direct or reflex sensory-motor irritability of the nerves, and, in particular, neuralgia. This operation should only be attempted when all other means of treatment have failed; but for the spinal nerves it should be preferred to either neurotomy or neurectomy. For the cranial nerves, we have said that it is necessary to be very reserved in its employment. Elongation is also indicated in traumatic contractures, tetanus, and reflex epilepsy, the surgeon being careful, in the latter cases, to elongate all the nerves which come from the focus of irritation, to interfere early, and to repeat the elongation a certain number of times, as advised by Johnston, if the first produces only a

[1] Wecker, Annales d'Oculistique, t. lxxxv. p. 134. 1881.
[2] Société de Chirurgie, 12 Avril, 1882.
[3] Lamarre, Contribution à l'étude de l'élongation des nerfs dans les affections médullaires. Revue de Chirurgie, Juin, 1881.

temporary amelioration. Finally, this operation may be practised in ataxic patients, especially when the lightning pains are strongly marked.

The elongation of spinal nerves does not present any special gravity, and in none of the cases, already numerous, which have been thus far published, has any grave accident supervened in consequence of the tractions exerted upon the nerve-trunks, contrary to what might have been supposed from the cases of sudden death occurring during reduction of shoulder luxations, which are explained by the dragging on the brachial plexus. But it is evident that this operation, like all surgical interferences, exposes the patient to the accidents and the complications of wounds. In regard to the functional activity of the nerve, we have seen that persistent paralysis of motility has never been described as a result of elongation of these nerves. We know that it is not the same with the cranial nerves, and that the harmlessness of their elongation is much disputed. In either case the surgeon should be guarded in the employment of chloroform, since this operation, more than any other, perhaps, exposes to reflex syncope which may readily prove fatal.

Operative Manual.—Should *general anæsthesia* be employed? Debove and Gillette reject the employment of chloroform, fearing a sudden arrest of the heart by reflex excitement. Quinquaud rejects it in order to recognize the existence of anæsthesia, which demonstrates that the elongation has been sufficient. Chiene and Blum administer chloroform, and I have likewise used it. I have also employed *local anæsthesia* by means of the ether spray. The pain at the moment of elongation is excruciating, but transitory. Most frequently, general anæsthesia ought to be resorted to.

The operation of nerve-elongation or nerve-stretching includes *four stages:* (1) the incision and search for the nerve, (2) its isolation, (3) its elongation, and (4) finally its replacement, and the dressing of the wound.

(1) The first stage demands a complementary chapter of operative surgery, which has already been sketched by Vogt. As in the ligation of arteries, the *incision* should be as much as possible parallel to the course of the nerve, and its length should vary with the depth at which the nerve is situated. Blum advises choosing for the incision, as far as possible, the point nearest to the supposed place of origin of the symptoms, and the employment of Esmarch's bandage to facilitate the search for the nerve. When the region permits it, Gillette thinks it prudent to keep at a distance from the spinal cord. It is sufficient to say that the incision should be made at the point where the nerve trunk is most accessible; Esmarch's bandage is commonly useless, and should be removed at the moment of elongation.

The *search for the nerve* should be made with as little injury as possible to the surrounding tissues. Elongation of the sciatic nerve has often occasioned a suppurating wound, which I attribute to the fact that tractions are exercised upon the muscles; sometimes they are separated with the fingers, but it is better to make a clean-cut wound.

(2) The second stage of the operation may present some difficulties, if the nerve is inclosed in a tissue of new formation, cicatricial or otherwise. When once the nerve is exposed, it is *isolated* like the artery in a ligation, with the forceps or grooved director.

(3) The most important stage is now reached, *the elongation* itself, which may be done either with the finger, with the forceps or grooved director, or, finally, with a blunt hook such as I have had constructed, simply provided with a groove, concave in one direction and convex in the other, upon which the nerve lies, or carrying a dynamometer at the middle part of its shank, as in Gillette's instrument; but when it comes to be determined what force should be used in drawing upon the nerve, we are obliged to admit, with Trombetta,

that the indications given by surgeons upon this subject are vague. Taking the sciatic nerve, for example, of which the conditions of elongation are best determined, it is seen that Billroth advises only to lift it up with the finger; Mac Farlane and Nussbaum, to make progressive traction sufficiently strong to raise up the limb; Patruban, to stretch it forcibly, so that the roots may participate in the elongation; Chiene, to draw it from above downwards and from below upwards, forcibly enough to raise the limb from the operating table; Spence, to fix the foot, and draw the nerve until it yields with a sensation of resistance having been overcome; Robertson, to draw strongly until a certain degree of relaxation has been obtained; Langenbeck, to draw with great violence; Blum, finally, to make slight extension if the function of the nerve is diminished or suppressed, and a sudden and violent extension if the excitability of the nerve is increased. As regards other nerves, the confusion is still greater.

To permit an appreciation of the tractile force applicable to the elongation of each nerve, Trombetta and Gillette have undertaken experiments, of which I have already spoken. These authors think that one-third of the force necessary to cause a rupture of the nerve is sufficient for its therapeutic stretching, and they recommend the employment of the dynamometer in the elongation of nerves, in order to know exactly what is done, and not to exceed the limit that has been marked out. Scheving advises to take as a guide in elongation, the production of anæsthesia alone, and to make mild and progressive traction until complete anæsthesia in the territory of the elongated nerve has been obtained, a condition which seems necessary, as we have seen, in order to obtain a permanent recovery.

This procedure appears logical, but it ought not to prevent the employment of the dynamometer, which will, no doubt, after a time, permit the tracing of more precise rules for nerve-elongation.

Before exercising tractions upon the nerve-trunk, care must be taken to have the limb immovably fixed, in order that flexion of the articulations may not allow the nerve to make too great a loop, since a too wide-spread destruction of the connections of the nerve with its sheath might interfere both with the nutrition of the nerve and with the results of its elongation.

In what direction must the tractions on the nerve-trunk be made? The majority of surgeons draw perpendicularly to the axis of the nerve. Gillette advises to pass the hook of his extensor-dynamometer through an elliptical orifice of 4 centimetres ($1\frac{1}{2}$ inches), with rounded edges, scooped out in a thick piece of board; the nerve, in being elongated, is pressed against the edges of the board, which serve as pulleys for changing the direction of the force, the perpendicular traction being thus accompanied, according to the surgeon of Bicêtre, by traction in both the centripetal and the centrifugal direction. Other authors draw in both these directions, holding the nerve between their fingers. But, as was said in the physiological part of this article, tractions on the peripheral end act rather upon the motility, and centripetal tractions upon the sensibility; it is therefore useless, and may be injurious, to make tractions upon the peripheral end of the nerve.

(4) To finish the operation it remains only to replace the nerve in its normal situation and to dress the wound. There is here an urgent indication to seek for union by the first intention, in order to avoid the formation of a cicatricial tissue capable of compressing the nerve. Therefore, I think, Lister's dressing should be employed, just as all the precautions of the antiseptic method should be observed during the course of the operation. During the first days of the after-treatment the limb should be kept immovable. Bramwell has advised making movements when cicatrization begins, so as not to permit the nerve to form adhesions.

In conclusion, I must describe the mode of elongating the sciatic nerve proposed by Trombetta, in accordance with the experiments of Vogt, and based upon the exhaustion of the elasticity of this nerve in movements of forced flexion of the thigh. It consists simply in flexing the thigh upon the pelvis, beyond a right angle, while the leg is kept extended upon the thigh. This manipulation determines, according to this author, a lengthening of the sciatic nerve, as great as a man could produce by drawing with all his strength upon this nerve. In experiments upon the cadaver, I have ascertained that, in forced flexion of the thigh, the leg being extended, the sciatic nerve is strongly drawn over the posterior surface of the neck of femur, and is flattened at this point. Trombetta does not believe that his procedure is applicable to the brachial plexus, because the movements of the arm are naturally too extended to allow of their being much exaggerated.

This procedure avoids the inconveniences of a bloody operation, but it necessitates complete anæsthesia, and clinical facts in sufficient number to allow an appreciation of its therapeutic value, are yet wanting; finally, as it requires very great flexibility of the coxo-femoral articulation, it is often inapplicable.

## III. Neurotomy and Neurectomy.

The name *Neurotomy* is given to an operation which by a simple section interrupts the continuity of one or several nerves. *Neurectomy* is the resection of a more or less extended portion of a nerve-trunk.

These two operations have the same immediate results, and the circumstances by which they are indicated are very analogous; hence it is convenient to study them together, in order to avoid repetition, pointing out, by the way, the peculiarities proper to each.

History.—Without speaking of the old surgeons who treated neuralgias, consecutive to wounds of the head, by surrounding the wound with deep incisions, it was about the middle of the last century that nerve-section appears to have been devised and practised for the first time by Maréchal, for the cure of *tic douloureux* of the face. But the inadequacy of this operation was soon recognized, and at the end of the 18th century, André, a surgeon of Versailles, treated this affection by the application of caustic along the course of the nerve, in such a manner as to destroy it for a certain extent—a procedure more certain, said Boyer (1822), than the resection of a portion of the nerve-trunk, but which was, notwithstanding, but little employed, except as a last resort after the failure of resection, on account of the extent of the ravages which it determined. The abuse made of nerve-sections and their bad results, which are easily explained, since they were almost exclusively applied to facial neuralgias, the most obstinate of all, caused them to fall into complete discredit, from whence they were again raised, about 1852, the period at which Roux, in France, Laurenzi and Borelli, in Italy, Schuh and Patruban, in Austria, and Wagner, in Prussia, again brought them into honor. Subsequently they were extolled by Sédillot and Nélaton, in France, and by Weber, of Bonn; but it is Letiévant to whom is due the most complete study of them which has been made.

Apart from neuralgias, neurotomy has been tried in cases of functional spasm, and in a certain number of spasmodic affections; in tetanus, by Larrey; in certain cases of chorea which are kept up by peripheral lesions, by Borelli, of Turin, Andral, and Malden; in hysteria due to a lesion of the peripheral nerves; in hydrophobia; in paralysis agitans; and in the delirium from nerve-

wounds. Optico-ciliary neurotomy has also been extolled as a remedy for sympathetic ophthalmia, and section of the sciatic nerve for the cure of Arabian elephantiasis.

Physiology.—I shall say here only a few words upon the physiology of nerve-section, referring, for that which relates to this question, to what was said in regard to accidental sections of nerves, their cicatrization, and the trophic lesions by which they may be followed.

Let me repeat only, that the section of a mixed nerve is generally followed by *paralysis of motion and sensation* in a great part of its territory, but that these sensory-motor disturbances may be more or less completely and more or less rapidly lessened, in consequence, no doubt, of the return of nervous influence through the anastomoses of neighboring nerves. This substitution may be such that the section of an important nerve does not cause any functional disturbance, even momentarily, as has been seen in several instances, after isolated section of the median nerve in the forearm, without lesion of either the radial or the ulnar nerve. It is proper to insist here very particularly upon these facts, which, although rare, may explain to us the failure of operative nerve-sections in a certain number of cases. It must be added that, according to Letiévant and Tripier, the functional integrity after nerve-sections is more apparent than real; indeed, according to the former of these authors, the preservation of movements is due to the combined action of muscles innervated by uninjured nerve-trunks (*substituted motility*). As to the sensibility, it is preserved, by anastomoses, at the periphery of the zone of distribution of the nerve, but it is wanting in the remainder of its extent; the tactile sense alone is partly preserved on account of the shock which is communicated to the healthy papillæ of the neighborhood, mechanically, absolutely as if the finger were touched by that of another person; tactile impressions are, indeed, transmitted in both cases by contiguity, but the painful and thermic impressions are null.

At other times, on the contrary, the paralysis extends beyond the domain of the cut nerve—an event which is explained by the occurrence of vasomotor disturbances.

After a certain period, about from four to six months, according to experiments upon animals, the phenomena of paralysis disappear by a process very different from that of which we have just spoken, by a true nervous regeneration, characterized by the appearance of nerve-fibres in the midst of the cicatricial tissue which unites the two ends of the divided nerve; this process has already been described on a preceding page.

When there is a loss of substance of the nerve, the immediate phenomena are the same, but the regeneration is more slowly effected; easily obtained after a resection of two centimetres ($\frac{3}{4}$ inch), according to Tripier, it becomes exceptional when the portion removed measures from four to six centimetres ($1\frac{1}{2}$–2 inches). These figures are furnished by experiments upon animals and are not strictly applicable to man.

Indications and Results.—In speaking of the history of these operations, the several affections in which section and excision of nerve-trunks are employed have been briefly mentioned. It now remains for us to study in detail the indications and results of these operations in each of these affections.

*Neuralgia* constitutes the least disputed indication for nerve-section or excision, and these operations have been practised a much greater number of times for this affection than for all others together.

In the pages which treat of neuralgia in general, I insisted upon the importance and the difficulty of making a precise diagnosis as to the nature of the

neuralgia, aeeording to the eonstitutional eondition of the patient; as to its eause, peripheral or eentral (eongestion, neuritis, aseending neuritis, eompression); as to its exaet seat, in the nerve-trunk, in the terminal branches, or in the eentral origin of the nerve. Finally, are we dealing with a reflex, or with an essential neuralgia?

From what has been said, then, three therapeutie indications are to be fulfilled:—

(1) To eombat the general constitutional state;
(2) To combat the loeal nerve lesion; and
(3) To eombat the pain.

I insist upon the neeessity of preeeding all surgical interferenee by an appropriate general and loeal treatment, eontinued for a sufficiently long time.

But frequently the diagnosis is ineomplete, and symptomatic treatment is employed in the endeavor to relieve the pain.

If the neuralgia is from a *peripheral cause*, the first indication is to endeavor to act upon this eause itself; if it eseape our means of aetion, we must have recourse to neurotomy; but Tripier reeommends, in sueh a ease, to interrupt all eommunieation with the nerve eentres by multiple sections. The operative proeedure will be relatively easy if the eause of the neuralgia still persist, but if it have disappeared, in eonsequenee of previous treatment, for example, while allowing the pains to eontinue, some difficulty will be experieneed in the operation. Tripier advises, in order to determine the seat of pain, to explore the nerve by pressure. If this, being applied over the nerve supposed to be affeeted, eauses the pain to eease, it is to this nerve that we must direet our attention. If the pain does not cease, it may be inferred that the lesion either involves the reeurrent fibres, or is eentrally situated. In order to ascertain whieh are the reeurrent fibres affeeted, pressure should be exerted upon the neighboring nerves.

In cases where the existenee of a *central lesion* is probable, some advise to refrain from interferenee, while others still authorize the operation as a last resouree, either in the hope of rendering the paroxysms less frequent by suppressing eauses of peripheral irritation, or even in the endeavor to obtain a eure ultimately, through conseeutive atrophy of the seat of the lesion. Vulpian and Dickinson have, in faet, observed, after a certain time, atrophy of the spinal eord at points corresponding to the origin of the nerves of amputated limbs.

If there is reason to fear that the ease is one of *ascending neuritis* or *perineuritis*, neurotomy beeomes neeessary, or rather neureetomy above the lesion, taking eare to examine the removed fragment, as advised by Brown-Séquard, in order to know if the nerve is still diseased at the point of seetion; and in ease of failure, a new seetion must be made at a higher point of the same trunk. The diffieulty of diagnosis in ascending neuritis aeeounts for many of the failures of neurotomy and neurectomy.

If the lesion is loeated in the *cutaneous ramifications* of the nerves, its dissemination and multiplieity of anastomoses may lead us to think that there is a eentral lesion, but there is almost always a more painful zone which seems the centre of irradiation, and the limits of which sueeessive eompression of the different nerve-branches will permit us to determine. Tripier advises, before resorting to nerve-seetion in these varieties of neuralgia, to treat them by applying very delicate cautery irons, so as to affeet the entire thickness of the skin. If this treatment does not sueeeed, a *polyneurotomy* should be performed, cutting first those branches, eompression upon which seems to eause a disappearanee of the pain.

According to some authors, Vulpian among others, the possibility of a lesion oeeupying the terminal plexuses has not been demonstrated.

To sum up, section of nerves is especially indicated in neuralgias which are primarily peripheral, but may also succeed in some neuralgias of central origin; it may therefore be said, with Dennis, that its principal indication resides in the violence of the pains, and in their resistance to other means of treatment.

In regard to the *choice of operative procedure*, the opinions of authors differ according to their theory of the mode of relapse. Tripier, who believes that the pain returns rather through the ways of transmission which have been allowed to persist, than through the cicatrix of the nerve, extols simple division of all the painful branches, *simultaneous* or *successive polyneurotomy*, and he thinks neurectomy necessary only when it is wished to remove an altered portion of a nerve trunk. Letiévant thinks that neurotomy, practised upon a single branch alone, should only be done if the neuralgia is traumatic; if it affects exclusively the sphere of distribution of a single nerve, or if it has begun thus very distinctly, and has only extended at a later period to the neighboring branches; if the paroxysm begins by a circumscribed pain of the nerve; if pressure upon the nerve which it is intended to cut diminishes or suppresses the paroxysm; and if there is no sign of central neuralgia: in all other cases he recommends simultaneous section of all the branches upon which there exist painful points (*points douloureux*). This author thinks, with Otto Weber and Virchow, that neurotomy is very probably sufficient to cure neuralgia when it is well applied. He recognizes only that neurectomy gives an additional security, and that it may be resorted to when the region permits this operation to be done without too much increasing the gravity of the prognosis, which is always more serious than that of a simple neurotomy. Such is not, however, the opinion of the great majority of surgeons of the present day, who see in the cicatricial union of the extremities of the divided nerve, the principal cause of relapse, and who consider neurectomy the best means of obviating its occurrence.

An operation recently proposed, the *elongation of nerves*, to which a special section of this article has been devoted, has been recommended for the cure of neuralgia as a substitute for the division of nerves, with or without resection. I may here add that, if elongation is perhaps preferable to section of nerves in neuralgias of the extremities, especially in the case of the mixed nerves, the motor function of which it preserves nearly intact, when, on the contrary, the cranial nerves are concerned—instead of elongation, which may act upon the nerve centres, exciting them, and causing either trophic disturbances, as in irritation of the branches of the trifacial, or arrest of the heart by reflex action—neurectomy is generally to be preferred, particularly for neuralgias of the fifth pair. For the facial nerve, however, if the case is one of painless spasm (*tic*) of the muscles of the face, it will be of advantage to employ moderate elongation, with crushing of the nerve, for example, between the blades of the forceps. Both reflex disturbance and permanent paralysis are thus avoided.

The surgical treatment, it is thus seen, should vary not only with each kind of neuralgia, but also with each kind of nerve, according as it is a spinal or cranial nerve, and, in the latter case, as it is a nerve of sensation or motion.

Sometimes section of the nerve is followed by a complete disappearance of the pain, at the very moment of operation—the recovery is instantaneous; but it is not unusual to see the pain continue for a certain time, and then gradually disappear. Again, the good effects of the operation may be much more slowly produced, the recovery being then attributed, as we have seen, to an atrophic process occurring in the nerve-centres as a result of the section of the nerve; but these cases must be received with hesitation, since they

may well be, at least in part, examples of spontaneous recovery, such as are observed now and then in neuralgias which have resisted all treatment.

In a great number of cases, after apparent recovery, more or less rapidly obtained, relapses occur. Thus, the statistics of 21 cases collected by Dennis show:—

6 relapses at the end of from 12 to 18 months.
3 " " " 6 to 12 "
4 " " " 1 to 6 "
4 " before the end of 1 month.
4 cases without relapse, kept under observation from 1 to 2 months.

This shows how necessary it is to be cautious in affirming the radical cure of a neuralgia, and during how long a period a relapse may be feared. This may depend, (1) upon the neuralgia being due to a primary central lesion, or to a central lesion consecutive to a peripheral lesion, and persisting after the operation; (2) upon the existence of an ascending neuritis; (3) upon the neuralgia having its seat in the recurrent fibres; (4) upon the painful nerve not having been cut; (5) upon an adjoining painful nerve having been left intact; or (6), when the relapse is delayed, upon the cicatrization of the two ends of the nerve. It is to avoid this accident that many surgeons prefer neurectomy to neurotomy.

It seems, finally, that in certain cases it is not positively known how the operation acts, or why relapse occurs. We may suppose that neuralgia is more often of central origin than is generally believed; and we may recall the fact that those who have suffered amputation frequently complain of neuralgia in the part of the limb which has been removed.

Subsequent operations will vary according to the cause to which it is believed that the return of the pains should be attributed. Among the most obstinate neuralgias are those of the face; they are also those in which surgical treatment is the most difficult from an operative point of view.

As regards the exact proportion of successes and failures of nerve-section, such as might be deduced from a complete statistical record, it varies according to the nature and seat of the neuralgia, and a gross number representing the average of all the operations performed upon all the nerves would be of no value. It may be said, however, that neurotomy counts a great number of absolute or relative successes, the value of which is the greater, since this operation is employed only as a last resort for neuralgias which seem incurable by other means of treatment.

Neuralgic pains may be also observed in the zone of distribution of a purely motor nerve. These pains may be due either to a lesion of the recurrent fibres, which the neighboring sensory branches send to this motor nerve, or to an alteration of the motor nerve itself, indicated by spasmodic movements, which are the immediate cause of the pain. In the first case, the branches which send the recurrent fibres should be cut; and, in the second case, if the motor nerve is to be dealt with, elongation, with or without crushing, should be first tried; and afterwards, neurotomy or neurectomy, if necessary.

Section of motor or mixed nerves has, moreover, been practised for the cure of *obstinate functional spasms*. It has been done especially upon the spinal accessory and muscular cutaneous nerves. In these cases, I repeat, elongation should be preferred to neurotomy, except, as has already been pointed out, in the case of the cranial nerves. It may, however, be necessary to resort to neurotomy, as shown by a case of Annandale's, in which resection of the spinal accessory nerve was required for the relief of a functional spasmodic torticollis of the sterno-mastoid muscle, which had resisted elongation.[1]

[1] Annandale, Lancet, vol. i. 1879, p. 555.

*Traumatic tetanus* has also been treated a certain number of times by nerve-section. All forms of this affection do not equally demand this operation; it should especially be practised when the contractions begin in the injured limb, and are accompanied by intense pain arising from the wound; when a nerve-lesion can be definitely recognized; when there is a tetanic aura at the beginning of each paroxysm; or when the presence of the symptom, pointed out by Wood, can be determined—the manifestation of pain in the wound at the moment that pressure is made upon one of the nerve-trunks which terminate in it. Even apart from these conditions, neurotomy should be performed, according to several authors, in all cases of tetanus accompanied by wounds. Under all circumstances, surgeons who recommend this operation insist upon the necessity of performing it early, before the secondary lesions of the nerve-centres are too extensive to yield to the general treatment which should always aid the neurotomy. The efficacy of this operation has been demonstrated by the instantaneous amelioration and rapid recovery which have followed in some cases. In respect to the choice of operation, there is no question of neurectomy, since the interruption of the nervous current should be only temporary; the choice is between simple and total neurotomy. The latter, true "nervous amputation of the limb," as it is called by Tripier, who recommends it as an exclusive method in the treatment of tetanus, has the serious inconvenience of leaving as a result a nearly useless limb, although its advocate affirms that every trace of paralysis should disappear at the end of about six months; it is also objected to this operation, that it multiplies the causes of irritation. Letiévant, nevertheless, believes that it may be properly resorted to when no special sign points to any particular nerve. As was said in studying the treatment of tetanus, recent cases seem to demonstrate that nerve-elongation is sufficient to arrest the symptoms, when it is employed in time; a few more favorable results, and it should be substituted for neurotomy, particularly since, even when combined with crushing, as is done by Verneuil, it is followed by a more certain and more rapid re-establishment of the nervous functions—a fact which should encourage us to resort to the operation freely and in good time, a condition essential to success in the treatment of tetanus.

Cases of *epileptiform convulsions* consecutive to traumatisms, cured by neurotomy or neurectomy, are sufficiently rare and sufficiently obscure for it to be impossible, as yet, to form any absolute conclusion in regard to them; it can only be said, that it is rational to think that these operations may be useful in certain cases. The same must be said in relation to *idiopathic epilepsy*, notwithstanding the numerous and interesting experiments of Brown-Séquard upon animals, from which Tripier thinks himself justified in concluding that neurotomy may and should be applied in all cases in which there exists an epileptic zone. This, however, is going too fast, and these experiments of the laboratory require confirmation from clinical observations.

It must suffice to mention the other affections to which Brown-Séquard believes neurotomy applicable in certain cases: these are *hysteria* from lesion of peripheral nerves—very difficult to diagnose—*hydrophobia*, *chorea*, *paralysis agitans*, and *delirium* from nerve-wounds. Nerve-section has also been practised in cases of *elephantiasis arabum*, so as to utilize the atrophy consecutive to the suppression of innervation. T. G. Morton has published the case of a negro, thirty-four years old, otherwise in good health, whom he treated by resection of one and a half inches from the great sciatic nerve, after unsuccessful ligation of the femoral artery and compression of the limb. This man had suffered for fourteen years with elephantiasis, limited to the right leg and thigh. Two months after the operation the limb had already

considerably diminished in size, and the scaly epidermis had desquamated, leaving a soft and pliable skin. Sensation had returned in almost all the territory of the cut nerve, and the skin did not present any tendency to ulceration.

Finally, section of all the nerves of the orbit (*optico-ciliary neurotomy*) has been extolled as a remedy for sympathetic ophthalmia. The efficacy of this operation is yet contested: while some, indeed, think it sufficient to arrest the development of symptoms as well as is done by enucleation, most oculists consider it only as a preventive operation, which should be done before the appearance of sympathetic ophthalmia, but to which it is not prudent to trust when once that affection is declared.

If we now endeavor to sum up the respective indications of section and resection of nerves, we shall see that neurotomy should be employed for tetanus and convulsive neuroses—affections which necessitate only a temporary interruption of the conductibility of the nerve—while neurectomy is to be preferred when it is desired to definitively abolish this conductibility, either to cure neuralgias or certain functional spasms, or in order to determine a permanent modification of the nutrition of tissues, as Morton did in the case of elephantiasis which has been quoted.

The consequences of neurotomy and neurectomy are usually very simple as regards the wound of operation, and union by the first intention will be most often obtained if the antiseptic method be employed; it is, moreover, especially desirable in an operation of this kind, in order to avoid the formation of a fibrous and retractile cicatricial tissue, capable of compressing the extremities of the nerves at any given moment, and of giving rise to new symptoms.

Operative Manual.—I need only mention, as a matter of historical interest, the *subcutaneous section* of nerves, which, at the present day, is almost universally condemned, and the few and questionable advantages of which are largely counterbalanced by the uncertainty of its result, which is usually incomplete.

It is then by means of an open wound that *neurotomy* must be done, with observance of antiseptic precautions, suited to render the operation as harmless as possible. The search for the nerve is made as in ligations of arteries, by taking as guides, lines of reference, muscular and osseous prominences, and the anatomical relations of the nerve-trunks (accompanying arteries, etc.). Further assistance may be gained, moreover, in the living subject, if the patient has not been rendered insensible, by excitations applied to the nerve, and by pressure exerted along its course. The rules suited for securing the discovery of each nerve-trunk in particular, have been traced by Letiévant in his *Traité des Sections Nerveuses.*

The operation includes the incision, the search for and isolation of the nerve, and finally its section. The latter is done with the bistoury or with scissors, which Letiévant prefers, since the knife, he says, drags upon the nerve-trunk. When multiple sections are desired, as recommended by Tripier, it is necessary to dispose them in such a way as to interrupt all communication with the diseased part while causing the least possible disturbance; this is done by carefully studying the painful points (*points douloureux*), and by having an exact knowledge of the distribution and anastomoses of the different nerves. However, except in tetanus, where this author extols total neurotomy at the beginning of the disease, nothing requires all these sections to be made at the same time, and sometimes it is advantageous, on the contrary, to divide them between several operations (*successive polyneurotomy*).

*Neurectomy* requires a larger incision and more extended isolation of the nerve. The difficulties presented by the application of this operation to the nerves of the face can be readily understood, since they most often must be sought for in the osseous canals which contain them, in proximity to important organs. It is in these cases that the choice of operative procedure presents a real importance; there exist, moreover, several methods for each of the nerve-trunks which it is necessary to resect.

The length of the piece of nerve which it is desirable to retrench, has not yet been exactly determined; as much must be removed as is possible without too seriously complicating the operation. It may be said that reunion of the two ends is exceptional after a resection of five centimetres (two inches). Some surgeons, in order more surely to avoid a relapse, followed the section of the nerve by avulsion, as extensive as possible, of its peripheral end.

In order to avoid cicatricial union of the two cut extremities, the older surgeons devised various procedures, all of which have fallen into disuse. Such were the bending back in loops of both ends of the nerve, or the interposition of a piece of flesh, as proposed by Malgaigne, and cauterization, as extolled by Boyer. The latter does not give any more security against relapse than does resection, and it, moreover, exposes the patient to accidents: it has been followed by tetanus, as in Frère's case, reported by Tillaux.

This study of neurotomy and neurectomy may be appropriately terminated with the relation of an interesting case, published by Drs. H. B. Sands and E. C. Séguin:—

A man, eighteen years old, was violently thrown backwards more than twenty feet, by the recoil of a cannon, on July 4, 1871. He lost consciousness for five minutes, receiving a contused wound of the right thumb, and a fracture of both bones of the forearm. At this moment, his right hand, he said, was as if it were dead. Three weeks afterwards, a violent neuralgia occurred along the course of the injured ulnar nerve, and in the little and ring fingers.

August 14. Drs. Sands and Séguin ascertained that the patient could not execute any voluntary movement, that sensation was abolished from the extremities of the fingers to the upper part of the arm, and that above the zone of anæsthesia there was hyperalgesia in the scapular and clavicular regions.

In view of the subjective symptoms complained of by the patient, these physicians were led to believe that there was an irritation of the nerve-trunks, produced by the fracture of the bones of the forearm, the fragments of which, no doubt, compressed or imprisoned the ulnar nerve. On the other hand, the paralysis and anæsthesia were too extended for the lesion not to reach much higher than the fracture, and, as a consequence, any operation practised at the seat of the solution of continuity, or below it, would have been useless. Dr. Séguin, believing that there was an ascending neuritis, recommended the application of powerful revulsives above and below the clavicle.

August 28. The pains were still more severe. Dr. Hamilton thought that there was a rupture of the nerve-trunks in the axillary region, and proposed amputation of the arm, which was performed on August 29. The median, ulnar, and musculo-cutaneous nerves were in a state of complete degeneration. They were neither compressed by the fragments of the broken bones, nor inclosed in the space between them. Temporary relief followed, but the pains returned.

Dr. Séguin proposed resection of the nerves which form the brachial plexus as close as possible to their points of emergence from the intervertebral foramina.

November 5. Neurectomy was performed by Dr. Sands, in the region of the neck. The right fifth, sixth, and seventh cervical nerves were excised, as well as several other nerves; all the fragments removed showed evidences of neuritis, with thickening of the neurilemma and granular degeneration of the fibres.

Marked benefit was experienced from this operation, but the patient, kept under observation for a year, still had obstinate pains occasionally.

This case is interesting, both on account of the difficulty of diagnosis and because of the different operations which were performed, the last—*neurectomy of the branches of origin of the brachial plexus*—being then practised for the first time.

The authors thought, with reason, that there had probably been produced, at the moment of the accident, a complete solution of continuity of all the nerves which were distributed to the lower part of the upper extremity.

# INJURIES OF THE JOINTS.

BY

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Injuries of the joints derive their great importance mainly from two circumstances, both of them mechanical in their nature:—

(1) The complexity of their structure, which renders a slight displacement of parts, or adhesion of surfaces, fatal to their perfect mechanical action;

(2) The presence of the synovial cavity, which on exposure to the air receives septic germs, and becomes a reservoir filled with putrid secretions, which both poison the whole system, and, locally, cause caries of the bones.

The great modern improvements in this branch of surgery are nearly all related to these two conditions, and derive their value from their power over them.

In discussing the subject of this article, I shall divide it according to the nature of the injuries, first taking up the important topic of dislocations.

### Dislocations.

A *dislocation*, or *luxation*, is a displacement of the articular surfaces of a joint from their normal, relative position. If these surfaces are entirely separated, the dislocation is termed *complete*. Where partial separation occurs, it is termed *incomplete*. If the joint cavity has not been laid open to the external air, the dislocation is *simple*. If it is thus opened, the dislocation is *compound*.

Causes of Dislocation.—The chief, *predisposing causes* of dislocations of the joints are laxity of the *capsular ligament*, or rents made in it by previous injury, and imperfections in the margins or other *bony and cartilaginous parts of the joints* from disease or former accidents. The normal structure of certain articulations predisposes them more to dislocation than others. Thus the shallow cup, and loose ligaments required to allow wide movements of the shoulder, render that articulation specially liable to the accident.

Malgaigne classified 603 cases of dislocation, with the following numbers for each part, viz.:—

| | | | | | |
|---|---|---|---|---|---|
| Shoulder | 370 | Thumb | 20 | Fingers | 7 |
| Elbow | 45 | Wrist | 16 | Vertebræ | 4 |
| Clavicle | 42 | Knee | 9 | Metatarsus | 2 |
| Hip | 40 | Radius | 7 | Patella | 2 |
| Ankle | 31 | Jaw | 7 | Pelvis | 1 |

Among the predisposing causes, *age* has some influence. Dislocations are most frequent in middle life, not only because at that period the necessities of active life subject men more frequently to risk of external violence, but also because the bones of children and old men are more prone to break than to be put out of joint.

An unnatural degree of *relaxation of joint-structures* is a very frequent, predisposing cause of luxation. This looseness of the capsules may be congenital, or may be developed by systematic stretching of a gymnastic sort. Strangely enough, the power of voluntary displacement of all the principal joints can be attained by long practice. Persons who have acquired this abnormal proficiency have travelled from city to city in the last few years, making a subsistence from the fees of medical students before whom they have exhibited the wonderful malpositions which they could produce at will in the joints of all the limbs.

The most usual *exciting cause* of dislocation is external violence; but in a few instances the luxation is the result of subjective influence, viz.: muscular tension, or the destruction of the boundaries of the joint by disease, or both causes acting in concert. Where great external violence is applied to a joint, the direction of the force will have much to do in determining whether the injury shall be a dislocation or a fracture. The strength of the capsular ligament is least on those sides of a joint where there is least frequent pressure; hence, if the force happens to drive the head of the bone in that direction, a dislocation will ensue, but if the movement is towards the places best guarded, the bone will generally give way instead of the ligament, as, for instance, in the hip joint, where dislocation in the direction of the thick Y ligament is seldom or never seen.

Symptoms.—The *rational symptoms* of dislocation usually are not such as to be of any value in differential diagnosis. The *local symptoms* only are of importance. *Deformity* due to three causes is found to exist whenever a bone is out of joint. (1) Flattening or depression of the region from which the articular extremity has been removed. (2) Prominence, from its presence in a new place. (3) Unnatural position of the limb or other member, from the resistance of the ligaments or muscles to the unusual traction. The member may be unnaturally lengthened, shortened, flexed, extended, rotated, adducted, or abducted.

*Mobility* as a rule is impaired, but is not totally abolished. The limb offers to the hand moving it a species of elastic resistance, wholly different from the unrestrained, natural sweep of the member in its normal condition.

Sometimes in causing the misplaced head of the bone to move across the torn fibres of ligaments which lie about it, a sensation is conveyed to the hand of the surgeon, faintly resembling *crepitus*. This differs so decidedly from the hard grating perceived by the hand or the ear in cases of fracture, that it seldom leads to difficulty of diagnosis.

In most cases of dislocation, rupture of the capsule takes place, but in a few instances ligamentous relaxation is so great that entire separation of the joint surfaces is found without rending of the fibrous connections. The synovial membrane seldom escapes more or less injury when a joint has suffered displacement. Inflammation from this cause may be of such severity that partial adhesion of the opposing surfaces, or even complete anchylosis, is a result.

When a dislocation is not reduced, various structural changes take place in the vicinity. The old socket sometimes becomes in a great measure filled up and obliterated, while in other instances it persists for a surprising length

of time, in consequence of the synovial membrane and secretions preventing the intrusion of new tissue into the cavity.

The pressure of the head of the bone at a new point causes fibrous effusion to take place around it, thus limiting and confining it in its movements, and so an imperfect articular cavity is produced in its new locality. Sometimes this is lubricated by a fluid resembling synovia, and answers a very useful purpose as a substitute for the original joint.

In old dislocations, adjacent organs often become modified in length and position to accommodate themselves to the new conditions. Important vessels may become so entangled in adhesions about a dislocated bone as to be torn by any efforts at replacement.

PROGNOSIS.—If a dislocation be reduced, there is usually almost complete restoration of the original usefulness of the joint. Yet several months or even years may elapse before the whole effects of the injury pass away, and in many cases absolute restoration is not secured. Occasionally, the inflammation resulting from the accident causes adhesions of such extent between the opposing surfaces that complete anchylosis is the result.

When a dislocation remains unreduced, of course the imperfection of the limb is far greater, although sometimes considerable mobility may remain. Compound dislocations involve great risk of suppuration and caries, often raising serious question as to whether amputation would not be more advisable than to run the dangers of a suppurative synovitis.

TREATMENT OF DISLOCATIONS.—The indications to be met in the treatment of dislocations, are (1) the reduction of the dislocation, (2) the prevention of inflammation, and (3) the restoration of usefulness to the joint.

*Reduction*—the chief indication—should in all cases be accomplished as early as circumstances will permit. The changes induced by inflammation, and by the welding together of the soft parts in their new relations, combine to increase the difficulty of reduction in proportion to the amount of delay in attempting it. If, therefore, there should be any doubt about the diagnosis after an ordinary examination, anæsthetics should be promptly and unhesitatingly employed to facilitate the investigation. The same agents assist greatly in reduction by causing muscular relaxation.

The older surgeons, on the supposition that the chief obstacle to reduction lay in the tension of the muscles, freely resorted to venesection, nauseants, and hot baths, as adjuvants to reduction. The progress of investigation has shown, however, that muscular resistance is only a small part of the force to be overcome. The chief obstacle to replacement is found to be the untorn portion of the capsular ligament, and we can readily see that nauseants and depressants can have no influence upon this kind of tissue.

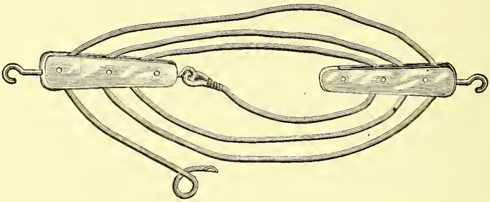
Still, though venesection and tartar emetic have become completely obsolete as aids in reduction, it is true that the muscles have some influence. To disarm their resistance, no agents are as effectual as chloroform and ether, as they not only produce relaxation, but also withhold the patient's mind and will from interfering with necessary manipulations. The abolition of pain also renders the surgeon's task more easy and more certain of perfect execution, even where there is no obscurity in diagnosis to require the anæsthetic.

The surgeon's hand is the principal means of force employed in reducing dislocations. Reductions made without the employment of mechanical apparatus are termed *reductions by manipulation*. When greater force is needed than can in this way be obtained, the coöperating hands of assistants frequently will give the requisite power. When, for any reasons, these are insufficient or inconvenient, mechanical contrivances are resorted to. The force employed

to draw the dislocated member in a direction away from the body, is called the *extending force*. As this force is often so great that it would drag the patient's body into a faulty position, a counteracting power is necessary to fix the body by acting in a contrary direction. This is denominated the *counter-extending* force.

The form of apparatus formerly most used to increase the power of extension, was the rope and pulley. The mechanics of this every-day contrivance

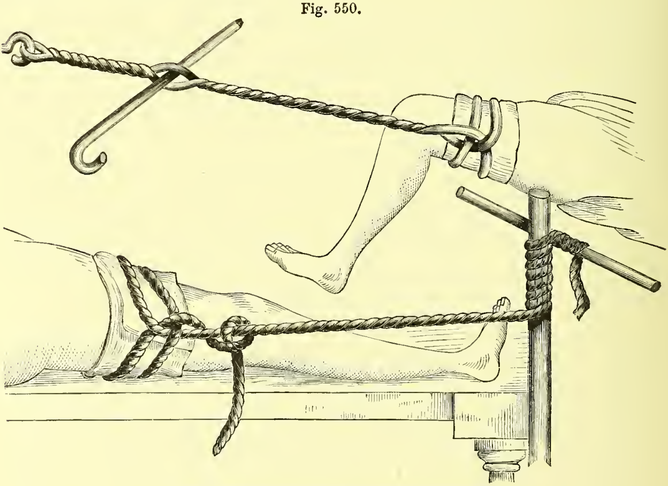
Fig. 549.



Triple pulley.

for multiplying power are too well understood to need explanation. Pulleys for surgical use do not differ from those made for other purposes. The common two- and three-wheeled blocks of ship-chandlers are equally efficient, though less elegantly constructed.

Fig. 550.



Spanish windlass and Spanish capstan, with clove-hitch.

When pulleys are not at command, extemporaneous contrivances can be made to answer a good purpose as means of powerful extension. A con-

trivance called by sailors the Spanish windlass, is made by twisting with a crossbar a number of cords, attached to the extending band at one end, and to some fixed object at the other. As the crossbar is swept around continuously in one direction, the torsion of the bundle contracts its length with irresistible power for a short distance.

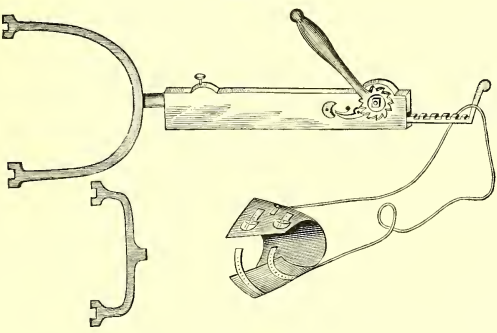
The power thus obtained is dangerously great, and, at the same time, the limits of motion are inconveniently small. The contrivance is much inferior to one used by the author in such cases, and called by some sailors the Spanish capstan, although it too is termed the Spanish windlass by many. The contrivance is more easily extemporized than the one commonly recommended by surgical writers, and is always preferred by sailors for simple increase of power within moderate limits.

To set up this apparatus, let the extending line be carried around a strong, movable stick or rail of any kind, and fastened by one or two turns to a crossbar, placed at right angles. For this purpose boatmen often use two oars. The handle of a broom, with a cane or rule for a crossbar, will furnish enough power for reducing dislocations. This strong bar is placed so as to rest across a doorway or window, the foot of the patient's bed, or some firm support, and the opposite end of the cord is attached to the limb, and extension to any amount is obtained simply by sweeping the crossbar around the other, winding up the cord upon it as a capstan winds up a cable.

The Spanish capstan is by far the best of all extemporaneous methods of multiplying the extending power. It gives any required amount of tractile force, it is easily prepared, and, instead of being limited to the few inches of shortening obtainable by twisting the cords of the Spanish windlass, it will haul in forty feet of line, if desired, as readily as one. In this method, also, the assistant whose hand turns the cross-stick readily estimates the amount of force, and avoids the unwitting application of a dangerous amount of tension.

*Jarvis's Adjuster.*—A very valuable instrument for all purposes of making extension was known to surgeons of the past generation as Jarvis's adjuster.

Fig. 551.



Jarvis's adjuster.

Although not at the present day manufactured and sold, on account of the general neglect into which it has fallen with the profession, this is still, for a certain percentage of cases, the most efficient means of treatment we have at command, and one unaccountably neglected by modern surgeons. For the

reduction of all dislocations requiring more force than the unaided hand can bring to bear, the adjuster is equally efficient, taking the place of pulleys, etc. But it is particularly helpful in cases where it is desirable to make use of powerful extension combined with manipulation. Fixed extension, by ropes and counter-bands, holds the patient firmly in a single position, and the direction of the extending force can be but little altered. The Jarvis adjuster, on the other hand, is attached entirely to the patient's body, and when it has been set in extension, the force of the pull and counter-pull is exerted independently of any outside support. The patient may be placed in any position deemed convenient, and may be moved about without interrupting the extension. The direction of the motion being in a straight line peripherally, in the axis of the limb, from the region of the joint as a centre, the desired extension may be had whether the limb be bent or straight; so that, while with fixed extension only one motion (rotation) can be employed, with the adjuster in place, flexion, adduction, and abduction, can be called in to assist extension. Improved methods of manipulation, together with the expense of the instrument, perhaps, have caused it to become nearly obsolete. It is no longer sold by dealers. Still, it remains true, that by its use a certain number of cases may be successfully reduced, which would resist all efforts with the pulleys, or by manipulation.

Whatever the source of power may be, the extending line or cord must be attached to the limb in such a way as not to cause injury to the parts subjected to its pressure. A secure hold is obtained by wrapping a damp towel about the limb at the place where the attachment is made. Over the towel, the band of linen or other strong material is placed in what sailors call the clove hitch (see Fig. 550). With Jarvis's adjuster, strong bands of linen webbing are buckled around the limb and furnished with loops for the attachment of the cords. Some surgeons make use of broad bands of heavy harness leather, held firmly about the limb by a row of buckles in much the same manner.

The extending apparatus of whatever sort, except the adjuster, requires some firm attachment from which the force may act. The post or foot-board of the patient's bed may sometimes be made use of. A crossbar set in a doorway or window will sometimes be the only means to receive solid support. Screw-hooks and rings, such as are used for this purpose, should be of large size, and so placed as to take hold firmly of the joists, and not merely the weaker parts of the wall. Carelessness in this regard may cause accidents.

Counter-extension may be made by the hands of assistants, or solely by the weight of the patient's body, when no great force is employed in reduction, and particularly if extension is made in an upward direction. Usually the body will have to be fixed when any mechanical aids are required to assist extension. Folded sheets, or other strong cloths, are to be passed about such parts as we wish to hold firmly in place. The ends of these bands of cloth are held in the hands of assistants, or are tied to some firm object.

The position in which a limb should be placed for reduction by extension is that which tends most effectually to relax (1) the untorn portion of the capsular ligament, and (2) the muscles whose resistance is to be overcome. In quality, the force should never be sudden or jerking (except in certain special conditions), but uniform and persistent, gradually increasing and overcoming whatever part of the resisting power may be due to muscular tension, and stretching or tearing, just to the requisite degree, but no further, the ligamentous bands which furnish the remainder of the opposition. Soft tissues yield gradually to this persistent extension, though they would be destroyed by sufficient traction to overcome their resistance if it were suddenly applied.

Extension may sometimes be accompanied by rotary and rocking movements of the displaced bone, so made as to favor its disentanglement from resisting bands, and especially to allow its insinuation into the lacerated opening or slit of the capsular ligament, made by the head of the bone in its escape from its normal position.

When the effort at reduction has been successful, the bone is often felt to slip into place suddenly, and sometimes with a dull sound, most inappropriately called in surgical terminology the "snap" of reduction. Under anæsthesia the sound is much less distinct, on account of the muscular relaxation thus obtained.

In the reduction of an old dislocation, the head of the bone makes its way so slowly into the socket as usually to cause no jerk or perceptible sound to indicate the precise time when it has arrived in its proper position.

*After Care.*—When reduction has been effected, the injured limb must be kept in such a posture, and so dressed and treated, as (1) to provide against the liability of the bone again to become luxated, (2) to combat the tendency to inflammation, and (3) to restore the mobility of the joint. The importance of these indications is in the order given.

Liability to redisplacement in simple uncomplicated luxations is great in a few joints, but not in the majority. It can almost certainly be controlled by care in keeping the parts at rest. Rest is the most important factor also in the prevention of excessive inflammation, and in the promotion of repair in the lacerated joint. Splints and retaining bands of various sorts, with or without permanent extension, are made use of to secure repose, and thus to prevent inflammation as well as displacement.

Both local and constitutional antiphlogistics are to be vigorously employed when necessary. Threatening synovitis, or such a degree of infiltration and swelling of the soft parts as would seem to endanger the future power of the joint, would form indications for their use. Synovitis occurring as a sequel of dislocation is to be treated in the same manner as when produced by any other traumatic cause. To restore the function of the joint, movements should be practised early in some cases, but very cautiously in others.

*Natural Bone Setters.*—The power or gift of "setting" dislocated bones, popularly supposed to reside in certain persons called "natural bone setters," is not usually exercised upon real dislocations. The sequelæ of various injuries in the form of false anchyloses, are by them falsely pronounced dislocations, and treated by various wrenches and jerks hereafter to be described.

## SPECIAL DISLOCATIONS.

### Dislocation of the Lower Jaw.

This accident is rare, constituting only about one per cent. of all dislocations. It may occur on one or both sides.

Causes.—The causes are external violence, as a blow or a fall, or muscular action. This may occur at a moment when the mouth is widely opened, as in the act of laughing, gaping, or vomiting. I have seen one case in which the bilateral dislocation was produced by the muscular action of vomiting after

a lobelia emetic. Sir Astley Cooper relates an instance in which dislocation was caused by the thrusting a large apple into a child's mouth. The muscles of mastication, like those elsewhere in the body, when brought into extreme contraction, sometimes become affected by a spasmodic shortening or "cramp" which the will is unable to control. The arrangement of muscles in the jaw is such that a powerful contraction at full extension, tends to force the heads of the bone forward, and may rupture the capsule. The internal pterygoid, inserted near the angle upon its deep surface, becomes a sort of fulcrum when the jaw is widely opened. The various depressor muscles at the symphysis act therefore upon the longer arm of a lever forcing the condyles with great power against the anterior wall of the capsules, and tending to break through them. The external pterygoids assist directly in pulling the condyles forward.

All these muscles are affected by the motor branch of the fifth pair, and when from reflex or other impression they act simultaneously, their power is very great. The condyles, which in the extended position are poised somewhat upon the summits of the articular eminences, are, by the spasmodic action referred to, made to spring forward in front of these prominences, and are immediately drawn upward under the zygomatic arches by the temporal and masseter muscles. The inter-articular cartilages still remain attached to the condyles in most cases.

Symptoms.—When both condyles are dislocated, the jaw remains open so that the teeth cannot be brought together, though the lips sometimes can be closed, the jaw itself remaining nearly immovable; a vacuity may be felt at the usual location of the condyles near the ear.

The amount of pain is variable.

In case the dislocation is unilateral, the opening of the mouth is less conspicuous, and the chin is thrown around, away from the dislocated side, causing the middle line of the incisor teeth of the lower jaw to be shifted considerably to the right or left of that of the upper incisors.

A sort of partial dislocation of the jaw is occasionally met with in persons with unusually lax ligaments, the head of the bone having slipped forward upon, but not beyond, the articular eminence, so as not to come completely in front of the root of the zygoma. A slight movement will cause the bone to return with a snap to its natural seat.

If the dislocation be not reduced, the movements of the jaw remain permanently impaired. Yet the patient often acquires considerably more power of moving the bone in its new and false position than one might have imagined possible.

Dislocations of the jaw of long standing have in some instances been reduced. Stromeyer, after twenty-five days had elapsed, succeeded in accomplishing reduction. Donovan, after twenty-eight, and Pollock, after one hundred and twenty days, were similarly successful.

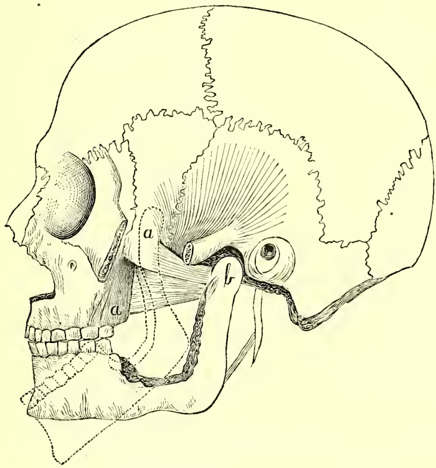
Treatment.—Usually reduction is not very difficult, and it may safely be attempted even when the dislocation is of long standing. The necessary steps in the manipulation are, (1) To depress the condyles below the level of the articular eminences, and (2) To force them directly backward to their normal positions, just behind these eminences.

To accomplish reduction most readily, the patient must be placed in a chair, while the operator takes his stand directly in front, having his thumbs wrapped in napkins to protect them against the spasmodic closure of the patient's jaws.

The surgeon places one thumb upon each posterior molar tooth of the lower jaw, while with his fingers he is ready to press upon the anterior por-

tion beneath the chin. He now presses strongly downwards with his thumbs, and at the same moment uses his fingers to push the chin in an upward direction. In this manipulation the thumbs become the fulcrum of a lever, the power being applied by the fingers at the chin, and the work done being

Fig. 552.




Showing action of external pterygoid muscle (*a b á*) in dislocation of lower jaw; the dotted line shows the position of the bone when displaced.

represented by the depressing of the condyles. When the condyles have been forced down below the level of the articulation, the first step of the operation is finished, and the surgeon then pushes the bone directly backward, when the reduction usually will be found complete. In difficult cases, corks may be substituted for the surgeon's thumbs between the back teeth.

## Dislocations of the Ribs.

Dislocation of the Ribs from the Vertebræ.—Many of the older authors have described instances of dislocation of the ribs from their articulations with the spinal column, but modern criticism has so far impaired the value of this testimony as to render it doubtful whether any of the recorded cases were correctly diagnosed, except one mentioned by Bransby Cooper, who found upon *post-mortem* examination an ancient dislocation of the seventh rib. During the patient's life, we have no means of distinguishing costo-vertebral dislocations from fractures of the necks of the ribs, and no method of effecting reduction if dislocation be present. Hence nothing can be said on the subject of the treatment of this accident.

Dislocation of the Ribs from their Cartilages. (*Costo-chondral dislocation.*)—This accident closely simulates fracture of the ribs, and indeed, during

life, it is not possible to determine whether the separation has or has not occurred exactly at the junction of the bone with the cartilage. Such a case must, therefore, be treated as if it were one of fractured rib—by replacement of the parts in the usual manner, with a bandage around the body [or strips of adhesive plaster], and a compress laid upon that part which shows itself most disposed to spring forward.

Dislocation of the Cartilages of the Ribs from the Sternum. (*Chondro-sternal dislocation.*)—The cartilage of the first rib has no synovial articulation, either with its rib or with the sternum. The next six costal cartilages are joined to the sternum by true articulations, with capsules and synovial membranes. These joints might theoretically be the seat of dislocations in two directions, that is, backward or forward. Clinical authorities are, however, for the most part silent about any but dislocations of the cartilages forward.

The most marked *symptom* in all these cases seems to be the hard projection formed by the head of the displaced cartilage, lying in front of its proper location.

The *treatment* consists in pressing the displaced cartilage back to its place, and there retaining it, as far as practicable, with bandages [or adhesive straps], and a compress. An assistant may aid the reduction by pressing his knee upon the spine, and drawing the shoulders backward. After replacement, the cartilage shows a decided tendency to spring forward, so that it may be difficult or even impossible to maintain the reduction. Something may be accomplished in assisting the retention by means of plaster of Paris, moulded upon the parts and held firmly in place by bandages around the body.

## Dislocation of the Bones of the Sternum.

Of this rare and dangerous accident Malgaigne has recorded ten cases, five of which ended fatally, owing to other complications. Traumatic cases are caused either by direct blows upon the bone itself, or by extremely violent backward flexing of the trunk, as when a person falls from a height, lighting upon a curb or fence. One case (Chevance's) was caused by violent, forward flexing of the body from a fall. Duverney, quoted by Malgaigne, reports a case in which the cause was lateral compression of the chest by a stone falling upon a man who lay upon his side.

Symptoms.—In all but one of the recorded cases of dislocation between the upper and the second pieces of the sternum, the second piece has been thrown forward in front of the lower border of the manubrium. In this instance, originally reported by Sabatier, and afterwards included in the memoir of Maisonneuve, the lower bone was found to have been forced behind the upper by the direct violence of a fall upon a stone. In a majority of instances, the accident is only an accompaniment of more serious injuries, involving the viscera of the thorax or the spinal column. Mediastinal abscesses are prone to occur, even when the viscera are uninjured, and, when they point externally, must be evacuated by incision or aspiration, under very strict antiseptic conditions.

Treatment will often be uncalled for, inasmuch as the patient is so often at the point of death from his other injuries.

In those cases in which recovery has taken place, reduction has been easily effected by placing the patient in a recumbent position, or by flexing his body

across cushions laid under the back in such a way as to make extension upon the displaced bones. In all cases the patient should be confined to the horizontal position until some union has been secured.

Dislocations of Ensiform Cartilage.—The *ensiform cartilage* has been dislocated in a number of instances, generally without fatal results. A blow upon the epigastrium is the only cause known to have produced this luxation. When it has occurred, the most prominent symptoms have been those due to the unusual pressure in this region caused by the displaced cartilage. Violent vomiting, with or without dyspnœa, is present, and the symptoms persist until reduction has been effected. Examination shows the cartilage to have been forced inward, leaving something of a depression at its natural location.

*Reduction* is indicated in all these cases to relieve the internal organs from the unnatural pressure, and after this has been effected, the symptoms may be expected to subside.

Sometimes the reduction may be accomplished by the fingers of the surgeon, elevating the cartilage to its place. In case the manipulation fail, an incision may be required, and instruments may be employed to aid in the replacement. In one case referred to by Poland,[1] after twenty-five days, during which time there were constant dyspnœa and vomiting, the cartilage was elevated by means of an instrument passed beneath it through an opening made for the purpose into the peritoneal cavity. Immediate relief was obtained, and the patient made a good recovery.

## Dislocations of the Clavicle.

Owing to the form of its articulations, the clavicle is, of all bones in the body, the most difficult to retain in position. Luxations occur both at the sternal and acromial extremities.

### I. Dislocation of the Sternal End of the Clavicle.

The sternal end of the clavicle may be dislocated *upward*, *forward*, or *backward*.

Forward dislocations are usually produced by blows upon the outer side of the shoulder, by which the clavicle is violently driven inward, so as to be forced at its inner end forward upon the sternum. In some instances the accident has resulted from severe muscular effort without external violence.

*Symptoms.*—The head of the bone lies beneath the skin, projecting in front of the sternum near its upper border, where it always may be felt, and, from the tumor which it forms, usually may be seen. In fat persons, however, or where much swelling has occurred, this symptom may be obscured.

The shoulder is thrown somewhat backward by the lever-like action of the bone, which forces its outer end in a direction opposite to that in which its inner end has been displaced.

Often the head is inclined toward the affected side by the patient's efforts to relax the painful tension of the sterno-mastoid. The prominence formed by the clavicular origin of this muscle stands out more under the skin than

[1] Holmes's System of Surgery, 2d edit. vol. ii. p. 572.

its fellow of the opposite side, being carried forward upon the sternum with the displaced head of the clavicle.

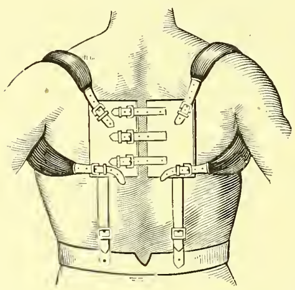
Careful measurement will show that the shoulder upon the affected side has fallen in somewhat towards the mesial plane of the body.

*Treatment.*—Reduction is effected without serious difficulty. An assistant should place his knee upon the spine in the upper part of the back, drawing the shoulders firmly backwards with his hands, while the surgeon, standing in front of the patient, forces the projecting end of the bone back to its place by means of direct pressure. The same result may be accomplished by having two assistants extend the arms powerfully by drawing in opposite directions, while the surgeon presses back the dislocated extremity as before.

In the treatment of this dislocation, the chief difficulty arises not in effecting, but in maintaining, the reduction. The bone lies so insecurely upon the narrow facet which it occupies on the sternum, that when once its ligamentous attachments are broken away, it has an inevitable tendency to slip out of its position.

The accompanying wood-cut (Fig. 553) shows the apparatus devised by Sir Astley Cooper for the after-treatment of these cases. Other surgeons, such as Dr. Folts, prefer to employ an axillary pad to act as a fulcrum, using the arm as a lever to keep the shoulder pried away from the body, and binding the elbow firmly against the side. A compress is placed over the sternal extremity of the clavicle, and a figure-of-8 bandage applied across the shoulders.

Fig. 553.



Sir Astley Cooper's apparatus for dislocated clavicle.

There is no authority for an invariable rule of procedure in these cases, and that method must be chosen which seems best adapted by trial to the case in hand.

The attempt to maintain reduction often fails in the hands of the most eminent surgeons. Even the celebrated Desault, who claimed complete success with his apparatus for retaining this bone in place, after reduction, is known in reality to have had a number of failures, and the same apparatus has proved very inefficient in the hands of all others who have employed it. Hamilton, in eleven cases under his observation, did not witness one instance of reduction being successfully maintained.

Dr. Gross suggests the fastening of the bone in place by silver wire; but as this operation must of necessity create disease of the sterno-clavicular articulation, with the possibility of suppuration and caries in spite of the most absolute antiseptic protection, it cannot be considered appropriate.

When the surgeon's appliances do succeed in maintaining the reduction, they should be worn continuously by the patient for five or six weeks, in order that firm union of the broken ligaments may be secured. But when, as usually happens, these efforts fail, the patient may have his liberty much earlier. Experience proves that when the head of the bone does not remain reduced, it nevertheless acquires a firm attachment in its new position, so that the shoulder is, ultimately, nearly if not quite as strong and useful as before.

In a young girl, in whom the altered position of the shoulder and the

irregularity at the top of the sternum might constitute a serious impairment of beauty, more time will be sacrificed by both patient and surgeon for the chance of a perfect recovery than in the opposite sex, where only the practical usefulness of the member is to be considered.

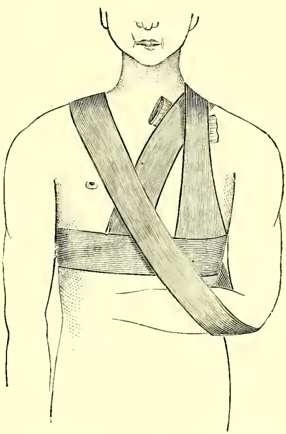
Upward Dislocation of Sternal End of Clavicle.—This accident is extremely rare, the total number of recorded cases being only twelve, to which I can add two others from my own practice.

The *causes* of the upward dislocation are the same as those of the forward luxation, viz.: blows or falls striking upon the outer part of the shoulder, and driving the clavicle inward in such a way that, partly by the direct force and partly by the leverage, the capsular ligament is torn, and the head of the bone is driven from its seat on the sternum. The inter-clavicular and costo-clavicular ligaments must also be ruptured in severe cases.

The *symptoms* resemble in the main those of forward dislocation, except in the position of the head of the bone, which lies above rather than in front of its natural seat. In Dr. Rochester's case, reported by Hamilton, the head of the bone lay in front of the thyroid cartilage, its presence in this extreme location giving rise to severe pain and dyspnœa, with loss of speech. The bone encroaches visibly upon the opposite side of the neck, with of course a corresponding falling in of the shoulder of the affected side.

Malgaigne's four cases, and that of Rochester, above mentioned, do not encourage us to expect perfect retention after the luxation has been reduced. The two cases which I herewith contribute, show one perfect recovery without deformity, as the result of a specially zealous and persevering trial, and one indifferent result, which represents the average success to be expected. A permanent displacement of half an inch or more will usually persist; but the functions of the shoulder and arm are practically unimpaired. The prognosis therefore is not grave.

Fig. 554.



Mode of applying adhesive straps for dislocation of sternal end of clavicle.

In the case of a young lady of Chicago, who suffered this injury, I succeeded, by special efforts, in effecting a perfect restoration of the joint. The luxation was produced by a fall from a carriage, and was not seen by me for several days. Upon first examination, it was found that the sternal end was displaced about one inch above its normal seat. There was no great pain or swelling, but the bone showed a constant tendency to reluxation, when pressed down to its place.

The dressing consisted of a firm compress of folded cloth upon the head of the bone and its whole inner third, held in place by broad straps of adhesive plaster, about two yards in length, carried upon the front and back of the trunk, down as far as the waist, and crossing each other upon the compress in two or three different directions. Other plaster bands were carried obliquely downward under the affected elbow from the opposite shoulder, lifting the arm upward, and prying the shoulder outward over a thick axillary pad. The head was kept bent forward by bandages, and rotated toward the

affected side so as to relax the tension of the sterno-mastoid muscle. The hand was kept supported in a sling. The dressings were occasionally reapplied for four weeks, after which they were removed, and the reduction remained perfect.

Such results are not generally obtainable, on account of the more severe nature of the injury, and the fact that the skin over the bone is often very intolerant of continued pressure.

*Treatment.*—Reduction would seem to have been simple in all the recorded cases, the treatment resolving itself into efforts to maintain the bone in its unstable socket, or rather facet, on the prominent top of the sternum.

Manipulation in a direction opposite to that of the force which brought about the dislocation, will promptly restore the bone to its place, from which it will promptly slip again when the force has been relaxed.

By some means the shoulder must be elevated, carried back, and drawn outwards, while a compress is made to hold the extremity of the bone in place. The arm must be supported by a sling and the elbow raised as in the dressing of a fractured clavicle. An axillary pad, rather large but soft, will afford the means of holding the shoulder out in its place. The compress upon the upper and inner portion of the clavicle must be held by bandages or adhesive bands, and the most perfect relaxation possible must be obtained in all opposing muscles, and especially in the sterno-mastoid and trapezius. Dr. Folts's apparatus, already mentioned, may furnish ready means of applying these principles. In each case the exact positions, bandages, and compresses, which seem on trial to be most likely to succeed, must be adopted and carefully preserved, as added facilities may, in this way, be hit upon, which no general directions can suggest.

Dislocation of Sternal End of Clavicle Backward.—*Causes.*—This dislocation is often produced by direct violence from in front, such as a blow upon the head of the bone, driving it back from its natural location. Like the upward and forward luxations, it also results from severe blows upon the outer extremity of the bone, and from compression of the opposite shoulders toward each other.

*Symptoms.*—Inspection, or the pressure of the finger, will always show the disappearance of the head of the bone from its socket, and by tracing its shaft inward, it is found to pass behind the sternum, carrying with it the clavicular origin of the sterno-mastoid, and thus rotating the head toward the opposite side. In some cases where the bone has been found above as well as behind its natural place, the tension of this muscle is supposed to have given it this direction. More commonly the displacement is somewhat downward as well as backward. The bone is moved somewhat toward the opposite side, carrying with it the shoulder. In its strange position among the important organs at the root of the neck, the bone may give rise to various alarming symptoms.

Dyspnœa and embarrassed deglutition have been present in most of the recorded cases. Once only is emphysema spoken of. Numbness and stoppage of circulation in the arm have been observed several times, from compression of the subclavian artery and of the brachial plexus. There would seem to be great danger of injury to the innominate artery should the right clavicle be affected, and very important nerve-trunks would also seem liable to laceration. In the few recorded cases, however, this has not occurred.

*Treatment.*—In most instances reduction has not been found very difficult, and, when accomplished, it has been more perfectly maintained than in the other forms of dislocation. Yet there is usually some slight deformity remaining. To effect reduction, the shoulder should be carried outward and

backward, or the outward movement alone may return the bone to place. The manipulations resemble those adopted for the other dislocations of the inner end of this bone, except that direct pressure, when used at all, must be applied to the sternum and not to the clavicle.

It has been found impossible in certain cases to accomplish reduction. Should this happen, and should there exist no obstruction to the respiration, to deglutition, or to the circulation of the arm, the surgeon may deem it best to leave the parts as he finds them, and may expect a nearly perfect restoration of the functions of the arm and shoulder. But when life is threatened by any dangerous symptom, or when, in the case of a young girl, it is deemed very important to prevent unsightly deformity, resolute measures must be resorted to. The overlying tissues may be divided, and the bone seized with lion-jawed forceps near its sternal end, so firmly that it can be drawn into place at the same time that assistants are drawing the shoulder outward and backward. Antiseptically performed, this operation would be almost without risk, and it might, like the subcutaneous section of ligaments in other regions, offer the only chance of success. The employment of a wire suture to unite the two bones, unless the dislocation be compound, is not to be recommended.

When, to relieve respiration or other vital function, the removal of the head of the bone from its position is a necessity, and other means have failed, the authorities recommend nothing less severe than excision of the sternal end of the clavicle, with due precautions against injury to the vessels beneath it. I am strongly of the opinion, however, that there could be no case of this sort which might not be relieved by dividing the clavicle with a chain-saw or bone-forceps near the junction of its inner and middle thirds, reducing the inner fragment by the help of the lion-jawed forceps, and treating the case afterward as a compound fracture, with the usual antiseptic precautions. If none of the vital functions were interfered with, neither excision nor division of the bone would be justifiable.

The after-treatment, when none of these severe measures have been resorted to, consists mainly in keeping the patient recumbent upon his back, the shoulders bent backward across an elevated cushion which is placed between them. Of course, care must be taken that no bands or compresses are allowed to rest upon the front of the clavicle, as these would tend to force the bone again from its articulating facet. Where cutting operations have been practised, the after-treatment is in principle the same, care being taken that the additional dressings used are not such as to cause backward pressure on the bone. After leaving his bed, the patient, for a week or two, should wear some dressing which will keep the shoulders drawn outward and immovable, and give rest to the muscles of the arm and chest. The axillary pad, with the elbow slightly elevated and drawn against the body by bandages or strong adhesive bands, will accomplish this end. From four to six weeks are required for the adhesions to become strong after rupture of these ligaments.

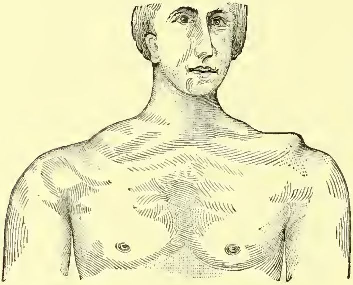
## II. Dislocation of the Acromial End of the Clavicle.

Surgical authors place all the varieties of this dislocation under two forms, the upward and the downward dislocations of the outer end.

Upward Dislocation of Acromial End of Clavicle.—*Causes.*—In almost every recorded instance of this accident, the luxation has been caused by the scapula having been wedged or jammed inwards, so as to drive it beneath the overriding, outer end, thus tearing apart the ligaments of the clavicle which bind that bone to the acromion process. It is caused, therefore, by

nearly the same injuries as those which produce luxations of the sternal end, that is, falls or blows upon the extremity of the shoulder. When the shoulder is powerfully driven inward, the force acting in the direction of the axis of the clavicle may produce dislocation of either the sternal or acromial end. The causes which determine one or the other accident we do not know. An upward blow striking the lower border of the bone has caused this dislocation, and, on the other hand, downward blows which spend their force upon the scapula without touching the clavicle, may tear asunder the acromio-clavicular bands.

Fig. 555.



Upward dislocation of acromial end of clavicle.

*Pathology and Symptoms.*—The rupture of the acromio-clavicular union by no means releases the collar-bone from its attachment to the shoulder-blade. The broad and strong coraco-clavicular band which anatomists describe as the *conoid* and *trapezoid* ligaments, is not injured in this dislocation, so that no great amount of separation can take place between the bones. When, therefore, the acromio-clavicular capsule is destroyed, and the escaped outer head of the clavicle springs upward from its shallow socket, it cannot, like the sternal end, slip freely to any distance, but is checked abruptly by the coracoid ligaments, and departs less than an inch from its place. Impairment of motion and loss of power do not appear as prominent symptoms. Pain may be wanting.

The shoulder droops and falls inward, so that the bone projects not only upward, but in all cases outward, forming a prominence above the head of the humerus, a little resembling the flattening of the shoulder in dislocation of that bone. The careful surgeon, however, can never mistake the true condition upon close examination. There is no real flattening nor vacuity beneath the prominence, in dislocation of the clavicle. On the contrary, the round head of the humerus can be seen and felt in its natural place fully up under the acromion, and a straight edge laid along the arm will not touch the prominence by an inch or more.

Beside this, the relations of the scapular processes and clavicle are easily ascertained by examining with the hand. In most cases the projecting head of the clavicle will be found to slip readily in and out of its place with a sensible "click," so that there will be little chance of mistaking the nature of the lesion.

*Treatment.*—Reduction usually can be effected by pressing upon the extremity of the bone. It could be maintained in the same way, were it not that continuous pressure upon a bone which is so superficial sometimes ulcerates the skin, and puts an end to that form of treatment. Surgical reports show a certain percentage of failures from this cause. But it is to be borne in mind that we have the whole outer third of the clavicle to be utilized, and that with broad compresses the risk of injuring the skin is less.

When gentle pressure upon the displaced head will not cause it to return, assistance may be rendered by having an assistant draw the shoulder outward as well as slightly upward and backward. The operation is simple and easy.

The maintenance of reduction is rarely perfect, on account of the unwilling-

ness of most patients to submit to prolonged treatment. The horizontal position would help greatly in the management of these cases, and with this aid no doubt most cures would be perfect; but as the injury is scarcely a disabling one, even to the arm, patients seldom consent to confinement, and can with difficulty be induced to wear the necessary dressings for the proper length of time. The greatest obstacle to perfect retention is the tension of the trapezius, which tends constantly to lift the bone out of its socket while the weight of the arm carries the shoulder downward.

The arm must be lifted, and the shoulder held outward by an axillary pad, as in luxations of the sternal end. Inclining the head and neck toward the affected side tends to relax the trapezius muscle, and is therefore useful in assisting retention, where patients will tolerate the awkwardness of the position. All these measures are, however, but subsidiary to the main, efficient means of retention, direct pressure upon the misplaced extremity of the clavicle, while the scapula is forced upward by bands beneath the elbow. A firm compress should be laid upon the flat extremity of the clavicle. In my own practice, broad and long adhesive straps, whose centres pass beneath the elbow of the injured side, are drawn tightly and crossed upon the compress, where the ends of the straps pass each other, being then continued down about ten inches upon the chest and back.

At first, an added band from the elbow across the sound shoulder will assist in lifting the scapula. When this dressing has been well applied, the affected shoulder is seen to be held several inches above the other, and, to the touch, the border of the trapezius seems much less tense. After the first week, the bone will usually be seen to hold its position more firmly, but will still slip out if the shoulder be allowed to droop.

Less rigid dressings may now be used, still embodying, however, the compress and straps to confine and raise the arm. The forearm is to be kept in a sling, and the elbow drawn toward the opposite side, as well as upward. In all cases which have come under my personal observation, the retention has been much aided by keeping the hand of the affected side well up toward the sound shoulder, as nearly as possible in the position used in applying the test for dislocation of the humerus.

It will not be possible, in many cases, to induce the patient to endure the constraint of keeping the hand actually capped over the point of the opposite shoulder, but it is quite readily brought and retained far enough up for the finger tips to rest upon the head of the humerus.

The following case, reported by Dr. E. Wyllys Andrews, resulted in perfect retention without deformity. Thomas W., a young man employed in a wholesale millinery establishment in Chicago, tripped over a wire while at work, and fell heavily upon the left shoulder, the direction of the blow being toward the median plane and the arm being close to the body. He was removed from the roof of the building where the accident occurred, and was seen by Dr. Andrews a few moments afterwards. A large contusion over the deltoid muscle showed where the greatest force of the fall had been expended, and the patient described his fall as having been so unexpected that the arm had not been put out as usual, so that he had been thrown violently, at full length. There were slight contusions on the outer side of the arm as far as the elbow. The patient complained of a sense of helplessness and dropping down of the shoulder, but not much of pain. He was found sitting upright in a chair, his head instinctively bent toward the left, hurt shoulder, which he kept lifted three-fourths of an inch above the other by pushing upward upon the elbow with the other hand. The elbow was also drawn somewhat across, in front, and hugged tightly against the body.

As first seen, the position was not very unlike that which afterwards proved to be the best suited to retaining the dislocated bone in place. The acromial end of the clavicle projected under the integument, about half or three-quarters of an inch above, and slightly outward and backward from, its articular facet on the acromion. Slight pres-

sure with the thumbs upon the projecting bone caused it to slip with a palpable, though not an audible "click," into its socket, where it seemed disposed to remain while the patient kept his head bent and his shoulder elevated, but whence it was seen to slip upon slight change of position. With a four-tailed bandage, applied as for a fractured clavicle, the elbow was pushed upward and the forearm drawn across the body, so that the fingers reached the tip of the opposite shoulder. That portion of the bandage which encircled the body, was tightly drawn, and was made wide enough to bind the lower part of the scapula tightly to the thorax. A broad band was carried directly over the injured shoulder from front to back, and beneath this was placed a soft but thick pad of folded, surgeon's lint, with a layer of cotton batting next to the skin, covering three and a half inches of the outer end of the bone. From first to last no pain or ulceration was caused by this pad. The tip of the elbow did become sore, and, after the first week, had to be relieved from pressure and kept covered with antiseptic cerate and gutta-percha tissue. Some other abrasions upon the outer surface of the arm were daily dressed and protected in the same way, and powerful pressure of the bandages over the dressing seemed in no way to retard their healing. The bandages were worn for four weeks, after which a broad band of adhesive plaster, with fan-shaped extremities, was passed across a small compress over the luxated bone, and was worn for two weeks longer. Union of the ligaments then seemed complete, and the dressings were removed. After three months no relapse had occurred, and there was no visible deformity.

In all cases there must be firm compression upon the flat extremity of the clavicle, and some means of raising the scapula by supporting the elbow. An excellent appliance for this and some other injuries about the shoulder is Folts's dressing, which consists of a strong band passing over the top of the shoulder, and buckled at its ends to a sling which incloses the flexed elbow. Still another method which has been successful, is to use a long elastic band, applied in the form of a species of figure-of-8, whose crossing is upon the compress over the head of the bone, one loop being beneath the elbow on the affected side, and the other beneath the opposite axilla.

The horizontal position in bed undoubtedly favors most perfect retention, and is of itself sufficient in some cases to insure success. This may often be a valuable aid in cases of young women, where it is of great importance to secure recovery without visible deformity. It is to be remembered that the skin covering the acromial end of the bone is rather intolerant of pressure, as it is also at the point of the elbow. Ulceration from pressure occurring at these points often defeats the surgeon's best efforts. When this occurs, the ultimate result is not serious as to the usefulness of the arm, but a slight prominence remains over the acromion process.

Dislocation Downward.—Downward dislocations of the acromial end of the clavicle are very rare, only five cases having been published. The injury seems to have been caused by violence exerted downward upon the clavicle. The most prominent symptom is the changed location of the head of the bone, easily felt under the skin. The treatment, as far as can be inferred from the recorded cases, should consist in drawing the shoulders outward and backward, by which reduction is effected. The bone has been found well disposed to retain its place when reduced. In order to insure retention, a broad bandage should be placed around the body beneath the axilla, to bind the scapula firmly to the thorax. When the lower extremity of the shoulder blade is thus compressed against the chest wall, the coracoid process will project well forward under the collar bone, and will effectually prevent its redisplacement.

Dislocation of the Scapular End of the Clavicle beneath the Coracoid Process.—This rare accident appears six times only in surgical literature. A fall upon the shoulder has been the cause in each instance. The symptoms are very well marked, there being a deep depression at the outer end

of the bone, and a corresponding lifting into prominence of the coracoid and acromion processes. The clavicle slopes decidedly more downward than its normal fellow, and its acromial end is felt projecting into the axilla. The small number of recorded cases of this injury, deprives us of any very copious knowledge of the results of treatment. In most instances the dislocation has been reduced by having an assistant pull the shoulder backward and outward, while the surgeon has grasped the bone, and has sought by manipulation to disengage it from under the coracoid process. Pinjon tried this method in vain, and the patient had the dislocation reduced next day by an empiric. It has been suggested, with some show of reason, that, instead of pulling the arm outward and backward as above recommended, thus putting the pectoralis major upon the stretch and causing it to resist the desired movement, it would be better to keep the elbow against the side, and pull the humerus outward by the hands in the axilla. Hamilton is of the opinion that this curious sub-coracoid dislocation, the belief in which rests solely upon the evidence of two surgeons, is wholly a fictitious injury, and an attempt at deception practised for the sake of notoriety.

Simultaneous Dislocation of Both Ends of the Clavicle.—This rare form of luxation is said to have occurred in a few cases. Such an injury, in a person not otherwise fatally hurt, might be reduced in accordance with the rules already given for the separate luxations.

## Dislocations of the Shoulder.

Owing to the anatomy of the joint, which fits it for very free motion rather than for secure repose, the shoulder is dislocated with great frequency. The main features of the accident are well agreed upon, but there are certain varieties of position and peculiarities of injury, which are yet matters of dispute among authors. American surgeons, who are still greatly influenced by Sir Astley Cooper's teachings, generally admit complete luxation in three directions, viz.: downward, forward, and backward, and with the frequency in the order named.

*Partial dislocations*, so called, are usually examples of faulty diagnosis, though such injuries do occur. It is possible that the force causing the accident may cease when the head of the bone has only partly rent its way through the capsule, and that thus the part may be held in a tight ligamentous grasp, without having fully escaped from the glenoid cavity. These cases are, however, very rare. Frequently the long tendon of the biceps is ruptured, and, a part of the anterior retaining force being thus removed, the head of the bone is pushed somewhat forward, and gives a false impression of partial dislocation. The inflammation and thickening of the anterior portion of the capsular ligament, by increasing the prominence, adds to the delusive appearance. Fractures of the border of the glenoid cavity may also give rise to slight displacements simulating partial dislocation. It is said that, in spite of assertions to the contrary, a true partial dislocation forward occurs, in consequence of the bone slipping forward to the coracoid process, and the biceps tendon gliding back behind the head of the humerus, and by its tension holding it forward against the coracoid, although the anatomy of the parts is such that the head could never rest in this position except for the support of the displaced tendon behind.

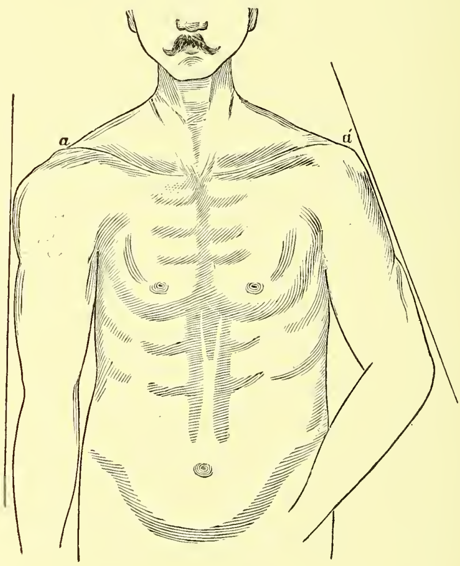
Old dislocations of the shoulder have generally been considered irreducible at the end of three months, but many instances of success have been recorded at later periods. Still, great care must be exercised in these cases, for fatal

injuries to the axillary artery and vein have occurred, especially when forced extension has been made in an upward direction. In some instances, a dislocation of the shoulder leaves a permanent deficiency in the capsule, of such a nature that reluxation occurs throughout the remainder of life from very slight causes.

SYMPTOMS.—There are several injuries which perplex the general practitioner by their resemblance to dislocation of the humerus, so that it is important to have a clear idea of the mechanism and symptoms of this lesion. The proofs of the luxation are these:—

(1) *Flattening of the Shoulder.*—In the natural position, the tuberosity of the humerus stands out laterally beyond the end of the acromion process, giving the deltoid region the beautiful curve so prized by sculptors and painters, and aptly called by the common people of some nations the "apple of the shoulder." When the joint is dislocated, the absence of the bone causes the deltoid muscle to fall in, and to present, instead of the proper curve, only a blunt angle, where it leaves the acromion, and to slope downward and outward almost in a straight line from its origin to its insertion. If the patient

Fig. 556.




Subglenoid dislocation of humerus, showing flatness beneath acromion. *a*, *a*, tips of acromion processes. The ruled lines indicate the test for dislocation by means of a straight edge laid on the arm.

is very fat, or the joint much swollen, this symptom is less conspicuous, but seldom altogether obliterated. If the finger of the surgeon pass downward

and outward from the acromion in examining a sound shoulder, it comes at once upon the tuberosity of the humerus, which may be grasped between the thumb and finger, and by rotation of the limb can be made distinctly obvious unless the swelling be very extraordinary. Slight differences exist among patients, or even between the two shoulders of the same patient in the distance of the tuberosity below the acromion; but in a true dislocation, the finger presses into a deep vacuity from which the head of the bone has completely gone.

(2) *Position of Caput Humeri.*—If now the head of the humerus be sought for, it will be found as a round, smooth, bony tumor, in the axillary, the coracoid, or the scapular region, according to the direction of its displacement.

(3) *Position of Elbow.*—If the patient be set upright, with both acromions on the same level, the arm of the affected side will be found to stand out obliquely from the body, so that, if the shoulders be kept level, the patient cannot voluntarily press his elbow against his side, and if the surgeon press it in, it springs out again as soon as the pressure is removed. If the dislocation is forward, the elbow is inclined outward and backward; but if the dislocation is backward, the elbow inclines more forward. These positions are due to the fact that, when the head of the humerus is thrown downward, the deltoid and the strong upper portion of the capsular ligament are put forcibly on the stretch, and throw the elbow outward, while if the direction of the dislocation be backward or forward, the untorn anterior or posterior parts of the ligament, and the corresponding parts of the deltoid, being stretched, act to give the elbow its characteristic position. If left to himself, the patient finds it painful to sustain the elbow in this position, and relieves himself by lowering the affected shoulder, and flexing his body in the same direction, so as to relieve the tension by allowing the elbow to hang more nearly vertically. In this position, the whole affected shoulder will be seen to be lower than the sound one.

(4) A favorite test of dislocation [known as *Dugas's test*], is to place the hand of the affected side on the prominence of the sound shoulder. If the shoulder is dislocated, the elbow will be elevated and will stand out prominently in front of the breast, and no moderate force will cause it to lie down against the sternum. This is a test of decided value, but, for it to be well applied, it is often necessary to disarm the patient's voluntary muscular resistance by the use of an anæsthetic.

(5) *Test by Application of Rule.*—Another striking symptom is elicited by taking a straight rule, and applying it along the outer border of the humerus, from the external condyle to the acromion. If the bone be in correct position, the rule will stand out some three-quarters of an inch from the acromion; but if the head of the humerus have moved inward, either from dislocation or from fracture of the neck or glenoid cavity of the scapula, the rule will rest against the point of the acromion, unless borne outward by unusual swelling or other deformity.

(6) *Character of Crepitus.*—The dislocated shoulder, when freely moved, sometimes yields a ripply, rubbing sensation, as of hard parts against tense ligamentous edges; but this is very different from the hard, gritty crepitus of newly fractured bone.

(7) Finally, if a dislocation be reduced, there is generally *no spontaneous tendency to a reluxation*, but in the fractures of this region there is often a strong tendency for the broken parts to slip out of place.

If, now, we bring together these symptoms in tabular form, and place after them the symptoms of the different fractures of this region, the means of diagnosis will be clear:—

### Signs of Dislocation.

(1) Flattening and vacuity below the acromion.
(2) Head of bone felt in axilla or elsewhere.
(3) Elbow held directly or obliquely outward.
(4) Hand being capped over sound shoulder, elbow cannot be easily made to touch breast.
(5) Rule on outside of arm touches acromion.
(6) No true bony crepitus.
(7) When reduced, bone remains in position.

### Signs of Fracture of Neck of Scapula.

(1) Flattening and vacuity below acromion.
(2) Head of bone and glenoid fragment felt in axilla.
(3) Arm hangs nearly vertically.
(4) Rule on outside of arm touches acromion.
(5) Hand being capped over sound shoulder, and patient under influence of anæsthetic, elbow can with moderate difficulty be pressed against breast.
(6) True bony crepitus.
(7) When reduced, parts again become spontaneously displaced.
(8) Coracoid process can be moved separately from body of scapula.

### Signs of Fracture of Glenoid Cavity.

Symptoms similar to fracture of neck of scapula.

### Signs of Fracture of Lower Rim of Glenoid Cavity.

All the symptoms of a true dislocation, but the bone slips out and in with slight force.

### Signs of Fracture of Anatomical Neck of Humerus (not impacted).

(1) Generally no displacement and little flattening under acromion.
(2) Head of bone not felt in axilla nor in any other abnormal place.
(3) Arm hangs nearly vertically.
(4) Hand being capped over opposite shoulder, elbow can be pressed against breast.
(5) Bony crepitus.
(6) If intracapsular, necrosis follows.

### Signs of Fracture through Tubercles, with Displacement of Lower Fragment inward.

(1) Some flattening below acromion, but finger finds head of bone there.
(2) Displaced fragment, if felt in axilla, lacks smooth round contour of head of bone.
(3) Arm hangs nearly vertically.
(4) Hand being capped over sound shoulder, elbow can be pressed against breast.
(5) Bony crepitus.

Some months after a fracture of the neck or tubercles of the humerus, we occasionally find surprisingly prominent exostoses in or near the axilla, causing the careless observer to fancy that the prominence felt is the dislocated head of the bone. In such a case, the presence of the tuberosity in its proper place beneath the acromion is sufficient to prevent a mistake. A similar growth from a fractured coracoid, neck of scapula, or glenoid cavity, raises similar anxieties, and the question of diagnosis must be settled by a rigid study of the mechanism of the injury, and of all the relations of the parts.

Ancient Dislocations of the Shoulder.—It has been stated that dislocations of the humerus become hopeless after three months. In some cases, however, these dislocations are reducible at a much later period, and efforts at reduction ought always to be made when the cases are seen within five or

six months after the injury. Subcutaneous division of portions of the resisting ligaments will sometimes greatly assist these efforts. This is justified when accompanied by full antiseptic precautions. It is to be remembered that there is great danger of rupturing the axillary vessels by making too violent extension in an old luxation at the shoulder. More than one fatal termination has followed this accident, where force has been incautiously used about the axilla in violent efforts at replacement.

Downward Dislocation of the Humerus.—Downward or subglenoid luxation, said by some to be the most common of all dislocations, is found by Hamilton to be the second in order of frequency. It consists of a downward and inward displacement of the head of the humerus into the axilla.

*Causes.*—Aside from direct blows, which not rarely produce dislocations downward of the humerus, falls upon the hand or elbow are found to be the chief causes. Any sudden raising of the arm to or above a horizontal position, may cause the bone to break through its capsule at its thin, inner and lower surface, and to slip downward into the axilla. This has been known to occur by the slipping of a crutch. I found it to have been produced, in one instance, by the act of striking out in swimming. The patient, a rather corpulent bnt not muscular man, felt a sudden pain and helplessness at the moment of throwing his arms forward to make a stroke, and had to be lifted from the swimming-bath by the assistants.

*Symptoms.*—Pain is usually rather severe, and quite often numbness, and a prickling or tingling sensation, are felt in the hand and arm. Very commonly the axillary vessels are so compressed that the radial pulse is imperceptible. The nsual roundness of the shoulder is lost, now that the head of the bone has left its socket, and the part has a flattened and angular appearance from the outward jutting of the acromion process, while below this there can be felt, if not seen, a depression or vacancy as compared with the opposite side.

More accurately to test the question as to whether the head has or has not left its socket, a rule may be laid along the outer aspect of the arm. This straight edge, in the normal condition of parts, stands off more than half an inch from the tip of the acromion. When, on the contrary, it rests upon this point with the arm hanging near the side, the sign may be taken as infallible that the head of the bone has left its true position, either by dislocation or by fracture of the scapular neck or glenoid cavity. (See Fig. 556.)

In corpulent persons, the vacancy below the acromion is palpable rather than visible; but I have never yet met with a case in which this sign alone would not have been sufficient to settle the diagnosis. A number of other symptoms are customarily observed: The elbow, instead of hanging close to the side, is carried more or less outward, on account of the throwing inward of the opposite end of the humerus. The head itself can be felt in the lower and anterior axillary border, more or less tightly held against the chest-wall by the tension of the pectoralis major and latissmus dorsi. It may be separated one or two inches from the coracoid process. The test of placing the hand of the dislocated arm upon the opposite shoulder is here applicable, as in all dislocations of the humerus. The elbow in this position cannot be made to come in contact with the body.

Anterior Dislocations of the Humerus.—These occur in two positions, giving rise to the *subcoracoid* and the *subclavicular* varieties of forward dislocation.

In *subcoracoid* dislocation, the head of the humerus rests upon the anterior surface of the neck of the scapula and border of the glenoid cavity, below the

coracoid process, or even a little further forward, where it is plainly visible, or certainly can be felt, through any amount of swelling of the soft parts.

The *subclavicular* dislocation is a rare form in which the head of the bone is found underneath the clavicle, and internal to the coracoid process.

The usual symptoms of humeral dislocation are present, as already described, the main differential signs of the anterior form of luxation being the different positions of the head of the bone, as seen or felt through the soft parts. In this form the elbow is often carried slightly backward, as well as outward from the side.

Posterior Dislocation of the Humerus.—Backward or subspinous luxations are not often met with. In this form the head of the bone is found to be behind and below its socket, having slipped back upon the scapula below the horizontal ridge, called its spine. In this abnormal position it is readily detected by the hand if not by the eye. The remaining symptoms are those common to all the dislocations of the shoulder. [The most striking symptom of this rare form of dislocation is the excessive prominence of the coracoid process, over which the skin is tightly stretched.]

Treatment of Dislocations of the Humerus.—In most cases an anæsthetic will be required, to aid the reduction. The steps of the operation are nearly identical in all the forms. Necessary variations will be obvious in the application of direct force to the head of the bone, to push it toward its socket. For the most part, extension and counter-extension only are invoked, as the essential elements in reduction. So simple and harmless are the traction methods, that they are by far the most frequently employed; but the use of the shaft of the humerus to obtain leverage, and other manipulations somewhat resembling those used in luxations of the hip, are advocated by a few surgeons. As in other joints, the principal obstacle to reduction is probably the untorn portion of the capsular ligament, which, in the shoulder, is always at the upper side; but Dr. Hamilton, of Rochester, considers the tension of the pectoralis major and latissimus the chief resisting forces, and undoubtedly the muscles exert more opposition here than in other dislocations, on account of the normally exposed and loose condition of the shoulder-joint. There will thus be seen to be an antagonism between the powerful muscles which draw the bone against the chest, and the strong, upper part of the capsule which is rendered most tense in the downward position of the arm; so that a position which most relaxes the latter will encounter most muscular resistance, and *vice versa*. Different authorities, therefore, claim advantages for each position, and success can undoubtedly be obtained with either, since the scapula is so loosely connected that ultimately the joint will probably be dragged in the most favorable position, in whatever direction traction be applied. Many times a change of direction is advisable, during the act of making the extension. My own experience, and that of many other operators, leads me to believe that the position with the shaft of the humerus at right angles to the body, is that which gives the greatest facility. This puts certain strong muscles upon the stretch; but has the obvious advantage of relaxing not only the untorn ligament above, but the powerful deltoid muscle.

*Description of Methods of Reduction.*—The following plans require no mechanical aids:—

*First Method.*—Let the patient be laid upon his back upon the floor, with suitable pillows and blankets, and then anæsthetized. The surgeon, after removing both shoes, seats himself at the affected side of the patient. Extending the arm to a right angle with the body, the surgeon grasps it firmly with both hands, making counter extension with the ball or heel of one foot

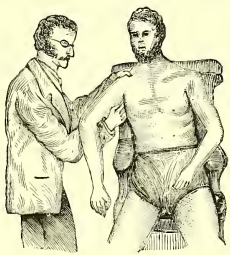
in the axilla, and with the ball of the other against the acromion process, being careful that the foot above the shoulder does not encroach upon the space which will be required for the head of the bone when about to slip into its socket. He then proceeds to make steady and gentle extension.

The upper, untorn part of the capsule in this position offers no resistance; but, on the contrary, aids in reduction when the head of the humerus has been well drawn outward, by pulling the glenoid cavity downward toward it. This tilting of the scapula is an important element in the reduction, and may be greatly aided by the foot upon the acromion, also giving it a downward movement at the proper moment.

In a large majority, perhaps nine-tenths, of the cases met with, this simple manœuvre will bring about reduction at the first attempt, and with very slight force of traction—less, indeed, than is required in any other method with which I am acquainted. Increased power of traction for older or more difficult cases is best obtained by means of a clove-hitch applied above the elbow, and a "jack towel" passed across the surgeon's shoulders.

*Second Method.*—Let the patient be placed in a sitting posture, without an anæsthetic, and a strong sheet be passed around the body just below the axilla, for counter-extension, and held by assistants upon the opposite side. This may be kept from slipping downward by means of a small strap over the shoulder. Other assistants make extension upon the dislocated limb at right angles to the body, the surgeon manipulating with his hands the scapula and humerus so as to make the articular surfaces approach each other. This method was a favorite with the older surgeons, but, since the introduction of anæsthetics, has been less in vogue, since the raising of an anæsthetized patient to a sitting posture would be a dangerous and unwarrantable act.

Fig. 557.



Direct reposition of dislocated humerus.

Instead of the sheet for counter-extension, Dr. N. R. Smith, of Baltimore, was accustomed to make traction upon the opposite wrist. In principle, these methods of counter-extension are the same.

While assistants are making traction, the surgeon may help the reduction in obstinate cases by having a band passed beneath the humerus near its upper end, with which he helps to draw the bone outward and upward.

In cases of difficulty it is allowable, after the failure of milder efforts, to make manipulations for the purpose of breaking further the fibres of the ligaments, and enlarging the narrow "button-hole" opening in the capsule. This is done by combining with the traction forcible rotation in a right and left direction, using force enough to only slightly lacerate the ligamentous bands, and to give a freer space for returning the bone to its articulation.

*Third Method.*—Another method has long been known among surgeons as "Cooper's method." It consists of downward extension, with the heel in the axilla, somewhat as in the plan first described, except that the surgeon places himself in a position parallel to the axis of the patient's body, and pulls downward, using at the same time the leverage of the shaft of the bone, to pry the head outward over the foot as a sort of fulcrum.

This method is the least economical of force, but, on account of the movable condition of the scapula, which allows it to be dragged around by the tension exerted at the upper edge of the glenoid cavity, very good results

are thus procurable. Although not equal to extension at right angles, it has always been a favorite method, and has succeeded in thousands of cases. While having the obvious advantage of relaxing the pectoralis and latissimus muscles, it puts on stretch the powerful deltoid and the upper untorn half of the capsule. Most obvious and important of the objections to downward extension, however, is the fact that the head of the bone is already below its socket; and it seems irrational to use force in a direction opposite to that in which it is desired to make the head of the bone advance. Were it not for the great mobility of the scapula, I am convinced that Cooper's method would never effect reduction at all. As it is, more force and time are needed for it than for any of the other plans described.

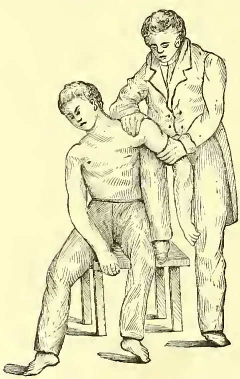
But recent shoulder dislocations are extremely easy of replacement, and Cooper's plan, though theoretically faulty, has probably been used in more cases than all other methods combined.

The operation is best conducted with the patient upon a lounge or couch; but the mattress may be laid upon the floor, or an ordinary table may be used in an emergency. Some surgeons prefer to use an axillary pad, as a roll of cloth or ball of yarn, upon which to rest the heel in making counter-extension.

By little and little the parts yield under steady traction; the glenoid cavity presents more downward, being drawn around as we have described, and the bone is felt or heard to slip into its socket. Either the clove-hitch and a strong linen band or rope, or the hands alone, may be used in making extension. Rotation to loosen fibrous obstructions is to be effected by using the forearm, flexed to a right angle, as a lever. I am strongly opposed to the use of Skey's iron knob in these cases, believing that the heel or a softer pad is equally efficient.

*Fourth Method.* (*Upward Extension.*)—In order most perfectly to relax that portion of the capsule which is still untorn, and also the deltoid muscle, some surgeons have advocated and practised reduction by extension obliquely upward and outward. This position puts to the extremest stretch the pectoral and dorsal muscles, and is probably, therefore, not quite as favorable as an intermediate position. Good results, however, are obtained by it, and it serves as one of the resources invoked in difficult cases. The danger of rupturing the axillary artery or vein is greatest when this position is chosen, on account of the distance through which the head is made to pass in sweeping the arm upward. It should be very cautiously employed in ancient dislocations, in which this accident is particularly liable to occur.

Fig. 558.



Reduction of dislocated humerus, with knee in axilla (Cooper's method).

*Fifth Method.*—Various methods have been devised for combining traction and leverage by placing a fulcrum in the axilla. Of these, Sir Astley Cooper's method of using the surgeon's knee, is to be mentioned as one frequently described, and probably quite safe and effective, but very little used by American surgeons. In this method, the patient is seated in a chair, the surgeon standing by his side with one foot upon the edge of the chair, and his knee in the patient's axilla, making counter-extension, while extension is made with the hands, the

knee serving also as a fulcrum on which to pry the shaft of the humerus, while the arm is at a right angle with the body, the forearm also being flexed to allow rotation to be made. For great force, *Jarvis's adjuster* is far more efficient and safe than the pulleys, as it enables the surgeon to use manipulation in connection with extension. Its use is to be reserved for ancient dislocations.

*Sixth Method.* (*Manipulation.*)—By manipulation is meant a combination of the various passive movements, such as flexion and extension, adduction and abduction, circumduction and rotation, by which dislocations of the shoulder can be reduced without the employment of great traction. Manipulation methods in the case of this joint do not afford such striking advantages as in some other parts of the body, notably the hip, but efforts have been made to classify and perfect these methods in reference to the various forms of the injury, and they deserve description. At present they are much in need of further trial, the evidence of their efficacy being solely based upon the small number of cases reported by the advocates of these methods, Prof. Henry H. Smith, of Philadelphia, and Prof. J. W. Hamilton, of Columbus. Prof. Hamilton[1] believes that the ligaments are less important than the muscles in opposing reduction, basing his theories of manipulation upon the idea of relaxing muscular resistance; but it is now known that dislocated joints are resisted in their return far more by the untorn parts of their capsules than by any other opposing element. In order to secure the least possible muscular resistance, this surgeon directs that the arm be slightly abducted and rotated inward, with the elbow bent at a right angle.

Obviously, this position puts to some tension the pectoralis, latissimus, triceps, and teres major, but it is claimed that the last named has little influence, while the other three are relaxed to some extent by the inward rotation. The pectoralis and latissimus not being attached to the scapula, but to points much further away from the joint, are more easily overcome than the shorter scapulo-humeral muscles. The following is Prof. Hamilton's plan of manipulation:—

Carry the injured arm from the side, keeping it horizontal, till, with the axis of the body projected upward, it makes an angle of forty-five degrees. At this stage, flex the forearm to a right angle with the arm. In a state of medium rotation the forearm will, at this stage, be in a direction perpendicular to the table. Keeping the forearm in this state of flexion, and for the present the arm in this state of rotation, let the member be grasped by an assistant, say, grasping the lower end of the humerus with the right and the wrist with the left hand. If the pectoralis and latissimus muscles are found tense, wait until they become relaxed. Now let the surgeon take his position at the head of the table, between the patient's arm and head. He will be able to place the tips of two thumbs on the tip of the acromion, and the tips of all the fingers on the displaced head of the humerus. Everything being thus made ready, direct the assistant to pull steadily but slightly with the right hand; at the same time, the surgeon presses in opposite directions upon the tip of the acromion and the head of the humerus, or, in other words, presses them gently towards each other. With the most insignificant expenditure of force, the bone will probably fall almost instantly into position. If it does not, rotate the arm, so that the forearm will be carried from a perpendicular, inward, to an angle of forty-five degrees, and repeat the movement; the rotation inward may be even more increased, or, this failing, outward rotation may be tried.

Fourteen successful cases are reported as treated by this surgeon in the manner above described.

[1] Ohio Medical Recorder, April, 1877.

After-treatment.—After reduction of a dislocated shoulder, the great proneness to reluxation requires that the arm shall be supported by binding the elbow against the body, and that a small axillary pad shall be used to keep the head of the bone well out. This may be worn six or eight days, after which more freedom of the arm can safely be allowed. The patient is to be cautioned that for several weeks he must on no account raise the arm above the shoulder-level, or put it to any violent use; but other movements should be practised, at least passively, and the axillary pad should be removed.

Dislocation of the long head of the biceps from the bicipital groove sometimes causes a puzzling deformity after a successful reduction, or even when there has been no luxation. Without being ruptured, this tendon is not certainly known ever to have been dislocated, although commonly so stated by old authors. No treatment is beneficial except rest to the limb.

Old Dislocations of the Humerus.—A majority of dislocated shoulders become incurable after twelve weeks, though a small number are reducible after a much greater length of time. The shoulder has been reduced after two years, to my personal knowledge, and doubtless many ancient cases have been too hastily abandoned as intractable, for fear of injury, their hopelessness being prejudged rather than satisfactorily tested, from the slight encouragement given in most surgical works.

*Jarvis's adjuster* is so essential an instrument in old dislocations, that little success or safety can be expected without it, save in cases not really very difficult. I do not know what success could be expected in ancient dislocations, where a combination of strong traction and very free manipulation offers the chief hope of loosening inveterate adhesions, were it not for the facility afforded by this inimitable piece of mechanism for obtaining these two forces in conjunction. Yet it is certain that the data upon which conclusions have been based heretofore have been mainly in the use of the old methods.

The *danger* attending efforts to reduce old dislocations of the humerus must be accepted as a constant factor, which should be well understood by the patient before submitting to this operation, exactly as in other surgical procedures. Besides the fracture of the surgical neck, and even of a rib, which have been known to occur in the violent efforts of operators to effect reduction, there is constantly to be feared a rupture of the axillary vein or artery, or both, accidents which usually have proved fatal. In one case this resulted from the sharp angle of a boot-heel carelessly used for counter-extension. Drawing the limb forcibly upward, subjects the vessels to a violent strain in all cases where they have become glued to the head of the bone by inflammatory adhesions in its new position. In the same manner, the innervation of the parts below the axilla may be wholly or partly destroyed. It is not known that any care can enable us to know what cases are most subject to this risk. The accident has usually occurred in the practice of eminent surgeons, and so frequently that the danger is certainly no slight one. In one remarkable case, recorded by Guérin, the surgeon tore an arm completely from the body of an aged woman, in making violent extension to reduce a long displaced humerus.

Notwithstanding the extreme caution necessary, and the actual danger to life, even with extreme caution, I believe that within six months after dislocation, a certain amount of effort is justifiable, when the patient so desires after a full knowledge of the circumstances, especially in those frequent instances where, from pressure upon the axillary trunks, the arm is rendered useless, or there are great distress and pain. Even after a long period, adhesions do not always take place to a serious extent, and reduction, when

secured, affords a nearly perfect restoration of the functions, no matter how long the time which has elapsed. Those cases in which extensive organic changes have occurred about the socket, are probably cases in which the new adhesions also are most developed, and in which reduction is therefore not easy.

The following remarkable case, which has not as yet been reported, is unparalleled in the records of surgery:—

Mr. B., a patient of my friend Dr. Rice, a prominent physician at La Moille, Illinois, met with an accident in November, 1877, by which he dislocated his shoulder. The patient, who was a farmer, failed for some reason to obtain proper treatment, and applied after eighteen months to Dr. Rice, who discovered the true nature of the injury, and made patient efforts to reduce the luxation. After using as much force as he dared, this physician pronounced the case beyond cure, and advised that no more hope be entertained of replacing the bone, as no nerves seemed pressed upon, and as the arm was still measureably useful to the patient.

In November, 1881, four years after the injury, the man was riding upon a horse, and at the same time leading a blind horse behind him, by a halter, which he had carelessly wound about the hand of the arm dislocated four years before. While in this position, the animal behind, becoming startled, suddenly jumped back, and Mr. B., who was unable to release his hand from the halter-strap, was dragged forcibly backward, so that the traction was both backward and, as he leaned further back, somewhat upward. The shock of this sudden strain was so severe that the patient was taken to his house and placed in bed, it being believed by himself and others that he was seriously hurt. He slept for some hours, the pain not being severe, and, upon awakening, himself discovered that his arm was changed in some way. Further examination showed that the luxation had been reduced, and the member soon recovered its mobility, and nearly its old strength.

From this extraordinary and exceptional case it is not to be concluded that there is ordinarily much hope in cases as old as the above. Much less violence has not unfrequently produced fatal results, yet a percentage of cases are doubtless reducible up to six months' standing by the use of the adjuster, and possibly by the subcutaneous sections already spoken of. I deem the upward extension to be dangerous in attempting to reduce ancient dislocations, but believe that traction at right angles to the trunk is reasonably safe, if not pushed to extreme violence.

When thoroughly relaxed by ether, the patient, being laid upon his back, may have Jarvis's adjuster applied, and carefully fitted; or, in default of this, a piece of apparatus specially constructed, with a rack and pinion, so as to allow of mobility. Least valuable and most dangerous of all appliances is the compound pulley, although this even will permit of rotation. Let the extending band be attached just above the elbow, the forearm being flexed at right angles, and let traction gradually be made at the same time that the arm is strongly rotated in either direction, to assist in loosening it from the bands of adhesion which have surrounded the head of the bone. Persistence rather than great force is what is needed to obtain reduction. Although no care will remove all risk of accident, the avoidance of extreme force in traction, and the patient repetition of the rotations, will very much abate this danger as compared with that of other methods. After long-continued efforts, the surgeon may be rewarded by feeling the bone slip into place, whereas the most energetic endeavors, continued for a few moments only, would have resulted in failure.

*Subcutaneous section* of the capsular ligament has been proposed and practised in this, as in other joints. I believe this operation to be nearly devoid of danger, when performed with full antiseptic precautions, and recommend it always, rather than permanently leaving the shoulder hopelessly maimed.

Recent cases which prove extraordinarily obstinate may also justify the same heroic measure. In other large joints, such as the elbow, I have often had recourse to this means of facilitating reduction, and believe it to be almost as safe as tenotomy, or as aspiration of an inflamed joint. By it I have succeeded in perfectly restoring joints which had been given up as hopeless, and certainly would have been so by any other means. No case has ever come under my care in which this operation has been required in the shoulder, but I certainly should resort to it rather than leave the joint unreduced, and in preference to resection. [Subcutaneous *osteotomy* of the humerus has been successfully employed by Dr. Mears, of Philadelphia, in a case of old, unreduced humeral dislocation, attended by great pain.]

*Resection* of the head of the humerus is a dangerous operation, but one which may be imperatively called for in cases where the axillary plexus is so compressed as to cause paralysis, and where every other resource has been invoked. The expedient, above described, of making subcutaneous, antiseptic divisions of the soft parts with the tenotome, would probably do away with the need of exsection.

## Dislocations of the Elbow.

Injuries of the elbow-joint occasion many errors of diagnosis, which render it important to consider the means of distinguishing the various lesions met with in this locality. The surgeon should have clearly in mind the four landmarks of this region, which are:—

The internal condyle.
The external condyle.
The olecranon process.
The head of the radius.

These four bony points always enable the presence of a luxation to be discovered. In the systematic examination of an injured elbow, the two condyles must first be examined, the patient by preference being anæsthetized, to determine their firmness of attachment to the shaft. When no movement or crepitus can be elicited by forcible pressure, neither the condyles nor the lower end of the shaft are fractured, and the possible existence of this common form of injury is eliminated from the differential diagnosis. After fully determining that the condyles are unhurt, the olecranon process must be sought for, in a position on a line approximately halfway between the condyles. The varying length of the inner condyle makes only a slight difference in this respect.

Below the internal condyle, a depression may be felt through the muscles.

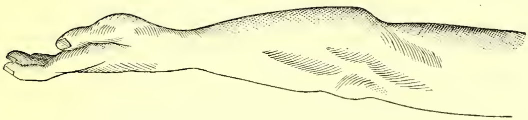
Below the external condyle, on the other hand, the surgeon should feel the fourth important landmark—the head of the radius—which may be made to rotate by turning the hand. The radial head is the most difficult of the landmarks to discover, but almost always can be identified by making firm pressure, and by rotating the forearm back and forth so as to cause the head to revolve under the fingers.

By comparison with the sound arm, it will not be difficult to settle the question of whether there has occurred any forward or lateral displacement of this bone. With the arm flexed, the olecranon should be on a line with the posterior surfaces of the humeral condyles, and, as already stated, halfway between them. A forward or backward displacement of this bony point at once arrests the notice of the surgeon, showing that he has to deal with a dislocation or a fracture.

Dislocation of the Head of the Radius Forward.—*Causes.*—Falls upon the elbow occasionally drive the head of the radius, by direct violence, into a position in front of the joint, and falls upon the hand have been said to cause the same injury. A radius has been known to be displaced forward at its upper end, simply by lifting a rather feeble child by one hand from the floor.

*Symptoms.*—In this accident the head of the radius is found upon the front of the humerus, where its presence is certainly proved by making rotation of the forearm while pressing with the thumb over the misplaced bone.

Fig. 559.



Forward dislocation of the head of the radius ; forearm supinated and extended.

Pressure in front of the external condyle discovers the vacuity from which the bone has departed. The forearm commonly is somewhat pronated, but may lie between pronation and supination, and may even be occasionally supinated. Some flexion usually exists, which can be increased to a right angle only. There is usually some pain and resistance when the limb is completely extended. The sudden locking of the bones which prevents the flexion beyond a right angle, occurs at the moment when the head of the radius strikes the front of the humerus. It is quite characteristic, and differs entirely from mere muscular resistance. The constant tension of the biceps muscle is the force maintaining the forward position, and the greatest obstacle to successfully retaining the bone when reduced.

*Prognosis.*—I have myself had no difficulty in the reduction of these cases. Sir Astley Cooper reported two failures in recent cases of his own, and some in the practice of other surgeons. Malgaigne, out of twenty-five cases, found six in which the diagnosis was not made until too late; eight in which reduction was successful; and eleven in which it failed. Hamilton met with three cases in which reduction had not been effected, and three in which, through mistaken diagnosis, no attempt at reduction had been made. One which had been treated by a member of the Sweet family of "natural bone-setters," was a complete failure.

It will therefore be seen that the surgeon can be by no means confident of success, even with the most faithful and careful efforts.

*Treatment.*—In many cases simple extension upon the forearm, with pressure of the thumb upon the head of the radius, will effect reduction. This Hamilton believes to be more successful when it is made in the direction in which the limb is found to point, that is, in a semiflexed position. After reduction, the limb must be maintained in a flexed position for several weeks, so as to secure a reasonably firm union of the capsule. The arm should be placed in a sling, and the patient directed never to lift the forearm so as to bring the biceps into a state of tension, as this would tend to draw the bone from its place. An angular splint at the back or front of the arm, is of use to assist in retaining the bones. After a few weeks, cautious, passive movements should be begun to prevent too much stiffening of the elbow. The luxation is one easily reproduced for a long period afterward, on account of the conformation of the articulating surfaces. It is easily seen, therefore, that the dislocation, if found to exist, may be only a reproduction of one which has

before been successfully reduced, and that therefore no blame can attach to the surgeon in case permanent deformity results from the after treatment not having been properly carried out by the patient.

Dislocation of the Head of the Radius Backward.—This accident is rather rare.

*Causes.*—Direct blows upon the front and upper end of the bone, and falls by which a similar impulse is given to it, as when a person falls upon his hand, are the usual causes of the injury.

*Symptoms.*—The head of the bone, as in forward luxations, can be detected in the position indicated by the description of the injury, that is, back of its normal place upon the external condyle, while over and in front of the latter, a vacancy exists, caused by the disappearance of the radial head from its articular facet.

The forearm, as in other dislocations of the elbow, is slightly flexed. It is said to incline to the prone position, and is bent more outward than natural, on account of the upward slipping of the radius, thus shortening the radial side. Flexion and extension, as well as supination, are very limited.

*Treatment.*—The opinions of authors are somewhat at variance as to the best means of reducing this luxation, and in fact it is not strictly necessary to pursue a uniform method. The following plan will accomplish the reduction as well as any that can be devised: Let an assistant seize the wrist and make traction, at the same time supinating the member strongly, while the surgeon with his thumbs and fingers presses the bone into position.

Dislocation of the Head of the Radius Outward.—It is doubtful whether this dislocation ever occurs primarily, or whether it is always secondary to the anterior or posterior form. The method of reduction is by making extension upon the forearm as before, and then pressing the bone toward its place.

Dislocations of the Upper End of the Ulna.—It is denied by some that an anterior dislocation of the ulna can ever occur without fracture of the olecranon, but one or two cases are recorded which seem veritable.

Extreme violence must be supposed to cause this injury, and the destruction of the ligaments is necessarily such that the bones may lie in almost any position. Practically, dislocations of the ulna occur in three directions, viz., backward, inward, and outward.

As to whether the ulna alone can be displaced backward, there is a good deal of contradictory testimony. The weight of evidence seems to show that in rare instances this has occurred, leaving the head of the radius still secure upon the external condyle. The treatment is in all details the same as when both bones are displaced.

Dislocations of the Radius and Ulna Backward.—The most frequent *cause* of this accident is found in falls upon the hand.

*Symptoms.*—Both radius and ulna are found back of the lower end of the humerus, so far as to allow the coronoid process of the ulna to be hooked behind the condyles, and to rest in the olecranon fossa, being drawn upward by the tension of the triceps muscle. The elbow is bent at an obtuse angle. The anterior and lateral ligaments are more or less torn, but the posterior part of the capsule is intact. The brachialis anticus and biceps muscles are often lacerated. The median nerve is often compressed, as shown by the numbness below. The ulnar nerve also is sometimes affected. As to whether the hand is pronated or supinated, authors make very contradictory statements.

Pronation is certainly more usual. There is little mobility, the bones being locked by the tension of the muscles and of the strained ligaments. The lower end of the humerus can be felt in the bend of the elbow, and the head of the radius and olecranon behind their natural position as regards the humeral condyles.

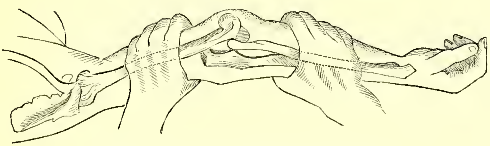
The differential diagnosis of this luxation ought not to be difficult, but it has caused many mistakes even in the hands of experienced surgeons.

From fractures of the condyles wherein the same backward projection of the olecranon may occur, this variety of luxation may be known by the fact that the condyles are seen or felt not to have gone back with the bones of the forearm, as well as by the absence of either crepitus or increased mobility. Anæsthetics may properly be employed in cases of obscure injury about the elbow, in order that a certainty of diagnosis may be arrived at, which will enable the practitioner to treat the case intelligently, and to avoid future blame for the imperfect results which occur, especially in fractures. Reduction is also easier with the aid of ether than without it.

Fracture of the coronoid process of the ulna, with backward displacement of both bones, is in fact a real dislocation complicated with fracture of the anterior border of the joint. The symptoms are the same, except as regards the presence of crepitus, and this is not always discernible; but the treatment differs in that special measures are required to prevent the bone from slipping backward again as soon as reduced. This occurrence is of itself diagnostic of fracture of the coronoid, and should be carefully looked for, and the fact determined as to whether or not there is a tendency to redisplacement.

*Treatment.*—Several methods of reduction are successfully practised. It is sometimes sufficient to over-extend and then suddenly flex the arm while keeping up a moderate degree of traction, as shown in the annexed illustration (Fig. 560). The older surgeons usually reduced this dislocation with

Fig. 560.



Reduction of backward dislocation of radius and ulna.

the patient in a sitting posture, by means of the knee in the elbow, as described by Sir Astley Cooper. As this would not be judicious when anæsthetics are used, this method is best modified so as to admit of keeping the patient in a horizontal position. What is desired is to place the elbow at a right angle across some fulcrum by which to pry or lift the coronoid out or back from behind the articular surface of the humerus, at the same time that extension is made upon the forearm.

Dorsey, instead of placing the knee in the bend of the elbow, had the wrist and forearm held by an assistant, while he interlocked his fingers above the elbow and drew the humerus strongly backward. Skey employed extension with the arm straight. Liston overcame muscular resistance by means of counter-extension against the scapula and backward traction on the forearm. Hamilton uses the knee, as directed by Cooper.

A modification of this method consists in placing the patient in a horizontal position, and making extension with the foot in the bend of the elbow,

the surgeon being seated at the patient's sound side, and placing his leg across the patient's breast. Anæsthesia may be employed with advantage. The foot, placed as above directed, serves for counter-extension against the force of the traction exerted by the hands grasping the forearm, and also as a sort of fulcrum, just as when the knee is used in the same way.

*Ancient Dislocations.*—Unreduced dislocations of the elbow become hopeless sooner than those of the shoulder. A large number become almost irreducible in six weeks. Even after this time, however, they should not be given up without trial. After nine weeks I have succeeded in effecting restoration of a luxated elbow by the use of Jarvis's adjuster, combined with subcutaneous section of the lateral ligaments under antiseptic precautions.

This resource I consider an extremely valuable one, and one also which is nearly harmless, if care be observed, in passing the tenotome, not to injure the ulnar nerve where it crosses close to the internal lateral ligament; with no possible harm, great assistance may be rendered by dividing the tendon of the triceps. Forced flexion and other movements also assist in breaking up adhesions.

Dislocation of the Radius and Ulna Outward.—Lateral dislocations at the elbow-joint are usually incomplete, though in some very severe injuries, both bones of the forearm are completely luxated, and may be found lying upon the side of the humerus, producing great deformity. When the bones are thrown toward the radial side, or outward, the study of the landmarks shows the olecranon to be removed too far from the inner, and to be placed too near the external condyle.

The radius is also thrust too far outward, and the cuplike cavity of its head can be felt with the fingers through the integument. The arm is somewhat flexed, because the olecranon, being carried away from its fossa, strikes the back of the external condyle, and prevents full extension.

The inner condyle is too prominent, and the depression in front of it more marked than usual. The diagnosis from fracture must rest mainly upon the absence of crepitus, and upon the immobility of the various bony parts.

Dislocation of Both Bones Inward.—Very few cases of this kind have been recorded. The head of the ulna rests in the hollow between the internal condyle and the trochlear eminence of the humerus. The deformity is not conspicuous, and this dislocation is often overlooked on account of the long, projecting internal condyle concealing by its prominence the misplaced ulna.

Careful study of the four landmarks at once shows the same condition of affairs as that already described in the outward form, only reversing the directions there named. The olecranon is much too near the inner condyle.

*Treatment.*—Extension of the forearm is made by assistants, while the surgeon presses upon the bones in order to coapt them. The reduction is easy, and little tendency is found to the reproduction of the luxation.

Dislocation of the Radius and Ulna in Opposite Directions.—Dislocation of the radius forward and of the ulna backward, is an injury of which at least four or five cases have been recorded. Traction and pressure upon the ends of the bones should be employed, as has been directed for each luxation. One or both bones may in this manner be reduced.

Compound Dislocations at the Elbow.—These are grave and sometimes fatal injuries. More conservative treatment is, however, justifiable here than in the ankle-joint or knee, because the danger to life is less. Prompt closure of the external wound, with full antiseptic treatment, may even secure a reco-

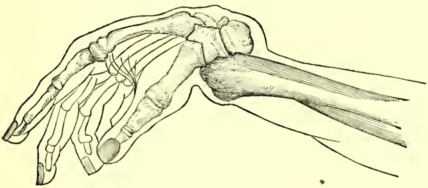
very without anchylosis, but this must always be exceptional. Amputation is seldom or never called for in these cases, but primary excision of the joint will often be the best course. This must depend upon the amount of injury which has been done to the bony structures, to a great extent, but somewhat on the extent of laceration of the soft parts as well.

## Dislocations at the Wrist.

Dislocation of the Carpus.—The older surgeons considered this accident extremely common; but modern investigations of the fractures at the lower end of the radius, have shown dislocation to be much less frequent than was once supposed. These luxations occur either backward or forward.

The *backward dislocation* is produced by violent flexing of the hand, or by blows or falls on the back of the hand while it is thus flexed. The carpus

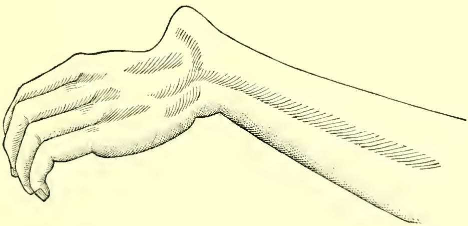
Fig. 561.



Backward dislocation of carpus.

is forced upward and backward upon the radius and ulna, while the latter make a large prominence in front of the wrist. Fracture of the rim of the joint often accompanies this injury. The chief danger in diagnosis is in confounding this luxation with fracture of the lower end of the radius. The mobility of the styloid process, even if crepitus be wanting, will usually

Fig. 562.



Forward dislocation of carpus.

make the differential diagnosis absolute. Where the radius is broken obliquely, so as to leave the styloid process attached to the shaft, the diagnosis must rest largely upon the presence of crepitus.

The *forward dislocation* presents a great prominence of the bones of the

forearm behind the wrist, and resembles in general causation and pathology the last-mentioned luxation, except as to the direction of the displacement.

Dislocations at the wrist are reduced without great difficulty by making traction upon the hand and pressing the bones toward their places with the thumbs and fingers. As in other joints, compound dislocations should be treated antiseptically. Excision, rather than amputation, should be preferred in these cases.

Dislocations of the Lower Extremity of the Ulna.—Luxations occur in which the lower end of the ulna is thrown decidedly forward or backward without the radius participating in the displacement. The causes in the few cases cited seem to have been various, including falls, muscular action alone, and, in several cases, simple extension, as by lifting the weight of the body by the hands. The fibro-cartilage is ruptured, and the extremity of the bone is thrown in front of or behind the radius, as the case may be, making either the forward or the backward luxation. The treatment consists simply in pressing the bones into place, in the forward form supinating the hand, and in the backward pronating it, to assist the replacement.

It is said by Moore, of Rochester, that the styloid process of the ulna sometimes becomes engaged under the annular ligament, so as to resist the reduction. He advises strongly to flex the hand, and abduct it also toward the radial side, in order to unlock the styloid process. If it cannot be so disentangled in cases where it is held in this way, a careful section of the border of the ligament with a tenotome, and under full antiseptic precautions, will be justifiable.

This injury very commonly is accompanied by fracture. The displacement of the fragments may prevent reduction in such cases, and if the deformity appear slight, it may be neglected, especially in cases of impaction, wherein it seems important not to dislodge the bone. If the deformity be very great, then the risk must be taken of dislodging the impaction. Anterior and posterior splints, with suitable compresses, may be used to retain the bone for several weeks after reduction.

Dislocations between the Bones of the Carpus.—These are rare, obscure, and meagerly described. Undoubted cases of dislocation of a single bone have, however, occurred. When found in time, such cases are to be treated by direct pressure, and such position of the hand as experiment shows to favor retention. Compresses and splints to maintain immobility are requisite in the after-treatment.

## Dislocations of the Hand.

Dislocations of the Metacarpal Bones.—The metacarpal bones are not often dislocated, that of the thumb being the only luxation at all frequent, and this only relatively so, as all forms are rare. The metacarpal bone of the thumb may be displaced either forward or backward from its articulating surface on the trapezium.

In the *backward* form of dislocation, the cause seems to have been extreme flexion, or the infliction of blows upon the extremity of the thumb, driving it back while flexed.

Reduction should be effected by extension upon the thumb, combining this with direct pressure upon the bone itself in the direction of its articular surface.

In *forward* dislocation, the thumb will be found to present a vacuity at the

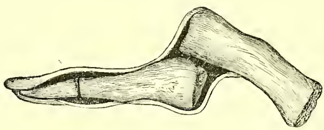
place of the joint, and a prominence in front. It is bent backward, and cannot be brought over to the little finger. Reduction is said by Cooper to be more difficult than in the last form. It should be attempted in the same manner, except that the thumb may be brought over toward the palm, to relax the powerful flexor muscles. The traction should be long continued and persistent.

Recourse may be had to the tenotome in making section of the lateral ligaments, but no division of the tendons is advisable or beneficial.

Dislocations of the Metacarpal Bones of the Fingers.—These are usually produced by blows given with the clenched fist, and the displacement is only partial. Whether in a backward or forward direction, the reduction is accomplished by making strong extension on the affected finger, and by pressing upon the prominence caused by the head of the bone.

Dislocations of the Phalanges of the Thumb and Fingers.—The usual direction of these displacements is backward, but forward luxations also occur. It is, in some instances, surprisingly difficult to reduce dislocations of these small joints, one difficulty evidently lying in the fact that the shortness of the fingers does not furnish sufficient hold and leverage for manipulation and traction. There is, however, some difference of opinion as to the main cause of this difficulty of reduction. It may be partly explained as follows: the proximal phalanx of the thumb, for example, being displaced backward, the sharp anterior ridge of the base of the phalanx rests just behind the terminal enlargement of the extremity of the metacarpal, held firmly in this position by the tightly strained, lateral ligaments. Extension tends only to put these ligaments more violently upon the stretch, unless proper manipulations are employed to release the bone. When in a semiflexed position, extension tends only to draw the member more nearly straight, and hence only increases the resistance, as the phalanx comes more nearly into a line with the metacarpal bone. But the strong lateral ligaments, acting as a fulcrum, increase the pressure of the two bones, which thus become more and more firmly locked. Hence the dislocation cannot yield to any amount of extension, unless it be applied in a suitable direction.

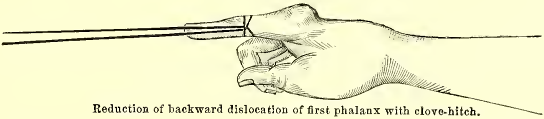
Fig. 563.



Forward dislocation of second phalanx of finger.

Considerable force must be employed, in whatever direction it be made, and to obtain this, a clove-hitch, Jarvis's adjuster, the "Indian puzzle," and

Fig. 564.



Reduction of backward dislocation of first phalanx with clove-hitch.

other appliances, are called into use. It is to be remembered that too great force may cause a stripping of the skin from the thumb or finger, while using any of the mechanical aids in traction.

In attempting reduction, the first efforts may be made by grasping the

member, and making extension in a straight position. Some cases are readily reduced by this simple means. Failing in this, extension may be tried in the flexed position, and by the aid of to and fro movements or rocking of the joint.

A band may be attached to the member by a clove-hitch if more force is desired, and any amount of additional power of traction thus obtained. After the tissues have been somewhat stretched, the effort may again be made to push the two bones into apposition. For this, the right-angled position is the most favorable, as it prevents, to some extent, the locking of the bones upon each other.

If this fail, the opposite manœuvre of forcibly straightening the phalanx may be resorted to; or strong backward flexion even may be attempted, in which position traction in a reversed direction may be applied, the thumb or finger being at the same time brought slowly around to a straight position.

When all other methods fail, subcutaneous division of the lateral ligament upon one or both sides, with perhaps section of the flexor brevis pollicis under antiseptic precautions, is justifiable, and rather than leave the deformity, the surgeon should adopt this operation, which is warranted by both reason and experience.

## Dislocations of the Hip.

The opinions and practice of surgeons in respect to dislocations of the hip have undergone great changes during the past few years, in consequence of investigations connected with the subject of reduction by manipulation. These investigations have been carried on chiefly by Professor Henry J. Bigelow, of Boston, who has courteously allowed the use of several illustrations from his excellent monograph on the subject.[1] It will not be possible, in the space assigned to the subject in this work, to give an elaborate discussion of the various conflicting opinions which in times past have been put forth by eminent writers; but it is safe to assert that, at the present time, the highest authorities in the profession are agreed, in the main, as to the truth of the statements which are about to be made.

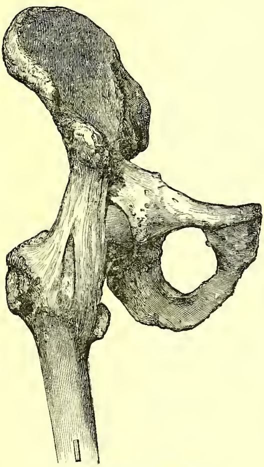
Anatomy of the Hip-joint.—There are two principal agents whose action confers upon a dislocated hip-joint the characteristic features by which the accident is recognized, and which also constitute the chief obstacles to reduction. These agents are, first, the untorn portion of the capsular ligament, and, secondly, the obturator internus muscle and tendon. The other muscles surrounding the hip have a certain influence, but experiments show that when they all are cut away, with the exception of the obturator internus, the characteristic features of the dislocation still remain, and the difficulties of reduction are not removed.

The *capsular ligament*—arising from the circumference of the acetabulum and parts adjacent—is inserted near the junction of the neck of the femur with the trochanter. It is, therefore, a tubular structure, complete in its entire circumference, but very much thicker at certain exposed points than at others. As the most frequent tendency to dislocation would naturally be upward, the superior part of this fibrous tube is always thicker and stronger than the part below. Other parts are also greatly thickened for certain purposes of security. From the anterior superior spinous process of the ilium, and from the bone below as far as the border of the acetabulum, arises a mass of ligamentous

[1] The Mechanism of Dislocation and Fracture of the Hip, etc. Philadelphia, 1869.

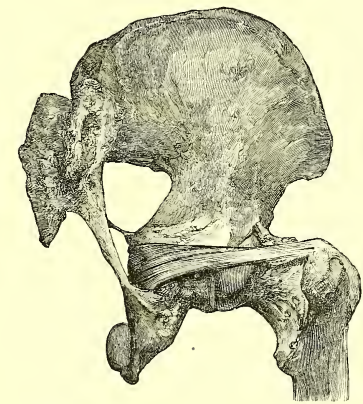
tissue, constituting a great thickening of the capsule at that point. This powerful band terminates very abruptly in front, where its border stands out almost as if it were a separate ligament. The posterior border is much less distinct, unless it be defined by cutting into its substance with a scalpel for purposes of demonstration. Instead of terminating by an abrupt line, it loses itself imperceptibly in the thick, strong substance of the superior and posterior portion of the capsular ligament. The strong band of fibres thus defined, passes downward in front of the neck and head of the femur, toward the trochanter major, near to which it shows a tendency to divide into two branches—an internal and an external termination. The former is inserted into the anterior and superior parts of the trochanter; the latter, passing more directly downward, is inserted into the bone nearer the lesser trochanter. The space between these branches is usually not absolutely void, but filled by a thinner part of the band. Still, when the whole ligament is laid bare, and when its borders have been defined with the knife, it may be supposed to bear a likeness to an inverted letter Y, and, accordingly, from this vague resemblance, has been called by Professor Bigelow the "Y" ligament; a name which, on account of its common acceptation, it is convenient to retain. This band has also been described by other anatomists and surgeons. It has been termed the "ilio-femoral ligament," and sometimes "Bertin's ligament." It is a portion of the capsular wall, of great thickness, often a quarter of an inch or more.

Fig. 565.



The Y ligament. (Bigelow.)

Fig. 566.



Showing relations of the obturator internus muscle to the hip-joint. (Bigelow.)

It is usual to describe four regular dislocations of the hip-joint, two of which are backward and two forward. In all of these the Y ligament remains untorn, whatever laceration may be produced in the rest of the capsule. By its tension this ligament determines the characteristic position of the various

forms of dislocation, such as flexion, inversion, eversion, adduction, or abduction of the limb.

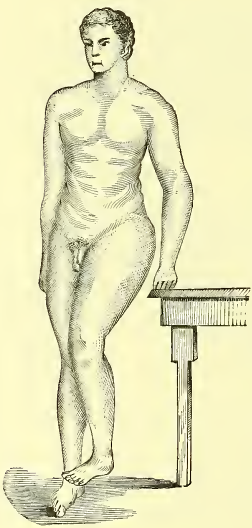
The *obturator internus* muscle has an important relation to the pathology, and also to the treatment of a certain class of dislocations. This muscle, from its origin in the obturator membrane and bony borders of the foramen, within the pelvis, converges its fibres into a tendon, which passes to the lesser sciatic notch and winds around a trochlear surface, to be inserted into the digital fossa on the great trochanter of the femur. The position of this muscle and ligament is such in relation to the displaced head of the thigh-bone, in certain cases of backward dislocation, that special manœuvres, which will hereafter be described, must, under these circumstances, be employed before the surgeon can hope to obtain reduction.

The four regular dislocations constitute those which alone are commonly met with, but in a few rare cases the Y ligament is so nearly sundered by the severity of the accident, that the limb ceases to fall into its normal characteristic positions, and assumes various accidental and irregular postures, hereafter to be noticed.

The tendency of surgical opinion at the present time is to look upon the untorn portions of the capsular ligament as constituting the chief source of resistance to reduction, and to attach far less importance than formerly to the more yielding and elastic resistance made by the muscles.

I. Dislocation upon the Dorsum of the Ilium.—This dislocation usually occurs as a consequence of force driving the femur upward and backward at a moment when it is in a flexed and adducted position. Reported cases show that falls, when the thigh is flexed and the patient strikes upon the knee, and violent compression in the same position, as when heavy bodies strike upon the back or hips of a person who is bent forward, are the usual causes of this dislocation.

Fig. 567.



Dislocation upon the dorsum ilii.

With the thigh in a state of flexion and adduction, any force acting in the direction of the axis of the femur is not received upon the firm support of the acetabulum, as much as upon the thin posterior wall of the joint-tube and ligamentum teres. Both ligaments are ruptured, and the head of the femur slips over the rim of the cotyloid ligament, and glides back and up under the gluteal muscles upon the dorsum of the ilium. While the head of the femur is forced back of its normal plane, it can only reach this position through the rotation of the shaft of the bone upon its axis, as the trochanter is held rigidly forward by the ilio-femoral or Y ligament. The thigh is, therefore, rotated inward and firmly held in this position until the dislocation is reduced. The head of the bone having gone backward, the knee is of necessity thrown forward, to some extent, by the bony conformation and by the unyielding Y ligament. This elevation of the knee is slight —only a few degrees above the normal plane—

but constantly present, and complete extension is as impossible as outward rotation. When the knee is forced downward, the pelvis tilts backward in a corresponding angle, so that, when the patient is laid upon a hard mattress, it will always be found impossible to bring his popliteal space and loins upon the bed at the same time. The limb is also adducted, and laid across the other, so that the great toe of the affected side points toward the instep of the opposite foot. It will be found impossible to evert or rotate the limb in any direction, for the tension of the Y ligament holds the trochanter so firmly against the pelvic bone that nothing short of rupturing its fibres or fracturing the femoral neck will allow the bone to rotate. In examining suspected cases of this dislocation, it is to be remembered that the capsules of the ankle and knee-joints in some individuals are quite loose, and permit the leg or foot to rotate through some degrees, while the thigh bone remains immovable. As already stated, the thigh cannot be adducted, nor even extended fully, save by a difficult tipping down of the pelvis, but adduction is easier, and flexion is most easy, because these movements do not tighten the Y ligament, but relax its tension.

The thigh, from knee-pan to ilium, is of course shortened by precisely the amount of upward slipping of the head along the pelvic bone. Sir Astley Cooper says that three inches, in many cases, is the measure of the difference of the two limbs. Writers give the usual amount of shortening as much less than this. Chelius, Miller, and Malgaigne, are of the opinion that cases occur in which no shortening is to be detected. Such cases cannot be examples of upward, but only of backward luxation. Hamilton, whose authority is great in this matter, concludes that the average of shortening is not more than one or one and a half inches, but concedes that occasionally it may reach three inches, as Sir Astley Cooper believed.

The *diagnosis* of upward and backward luxations of the thigh should present no insuperable difficulty if full opportunity be allowed for investigation. For the examination, the part should be thoroughly exposed, and the patient may be placed in a variety of positions while efforts are made to test the mobility of the limb and to obtain its measurements. The differential diagnosis is not perplexing when the history of the case is known.

Fracture of the neck of the femur presents only a part of the symptoms of dislocation, yet might be mistaken for it without careful examination. Crepitus, which would prove fracture to exist, may not be present, or, in case of impacted fracture in the cancellated structure, it may be deemed highly essential not to dislodge the impaction. Shortening usually occurs in fracture of the neck, but not so uniformly nor to so great a degree as in upward luxation. The diagnostic difference in the symptoms lies in the different position and mobility of the limb in the two cases. No simple fracture of the neck can give the distinctive position and behavior of this dislocation, viz., inward rotation, flexion, and adduction, with inability to rotate outward or abduct the limb. On the contrary, the foot is commonly everted and the limb in full extension. The thigh can be moved in all directions, with no resistance other than that caused by muscular opposition on account of pain. Fractures of the femoral neck occur in old persons, as a result of sudden falls or missteps—much slighter injuries than those required to produce dislocation.

Displacements upon the dorsum of the ilium occur frequently as a result of hip-disease. In the great majority of so-called spontaneous luxations, the real anatomical change consists in almost total destruction of both the acetabulum and the head of the femur, so that the joint proper is no longer in existence. It is scarcely proper to term these cases of dislocation. They are rather instances of upward and backward slipping of the shaft of the bone, following the destruction of the joint by ulceration. From hip-disease,

there ought to be no possible uncertainty in distinguishing the traumatic luxation, by the history and symptoms as given above. I have known cases, however, in which the displacement of hip-disease in the third stage occurred in such a fashion as might have led to mistake in diagnosis, had no inquiry been made as to the previous soundness of the limb.

A boy of scrofulous diathesis entered Mercy Hospital with chronic morbus coxarius in the third stage, the hip and thigh being much distended by a purulent accumulation, but the bone not yet having been displaced, nor the limb shortened. Incision and evacuation of the abscess with probable exsection of the hip were advised, and the operation was set for the following day. During the night, without any external violence, and without attracting the attention of patient or attendant, the femur slipped quietly from its normal position, and in the morning presented to the house-surgeon the usual aspect of dislocation upon the dorsum ilii. Upon exploring the abscess, the head of the femur was found to have its upper side diseased, but its greater part was still covered with cartilage. It lay on the dorsum ilii as in a dislocation, having escaped from its socket through an ulcerated notch in the rim, of only sufficient breadth to allow its displacement. The operation was completed by exsecting the joint, and was followed by a good recovery.

A case of hip-disease such as that above related, as closely simulates one of traumatic luxation as any that occurs, there being no external sinus, and the displacement being sudden; yet it would seem unnecessary to warn a careful surgeon against the possibility of mistaking the two affections, were it not that a number of cases are on record in which this very mistake has been made.

*Dislocation into the Sciatic Notch.*—Some authors speak of a dislocation almost directly *backward into the sciatic notch*, but all backward dislocations *above the tendon of the obturator internus*, are in reality but of a single species. Their pathology and symptoms are essentially similar, and they ought not to be separately described on account of mere differences in degree of shortening, adduction, or inversion of the foot. On the other hand, dislocations of the head of the femur *below the tendon of the obturator internus*, have been shown by Bigelow to be specifically distinct from other backward displacements, in reference to both pathology and treatment, since the tendon of this muscle, being wound tightly across the femoral neck at its inner surface, makes a peculiar obstacle to reduction. This form of luxation will be separately considered.

*Treatment of Upward and Backward Dislocations.*—The treatment of all the backward or dorsal luxations above the obturator tendon, is virtually the same. It may be noted that, in this particular dislocation, the methods of reduction in vogue in Cooper's day have practically become obsolete during the last decade, through the development of the manipulation method.

The revival and perfection of this method of reduction in hip-dislocations, is an interesting illustration of the value of exact pathological knowledge. Reduction by manipulation had been practised in a haphazard way for ages, without having attained the requisite degree of perfection, in any special class of luxations, to supersede the traction method. Its study and its rules of procedure were so purely empirical and so often unreliable, that no great value was attached to them, although in some cases they were identical with the precise methods which modern investigation has shown to be most successful.

In the hip, the basis of the system is the knowledge of the Y ligament in its relative position to the head and neck of the thigh-bone, in their several situations after dislocation. The various flexions, rotations, abductions, or adductions of the thigh, by which the head of the femur may be moved without encountering the unyielding resistance of this ligament, or may be

disengaged from its grasp, constitute the details of the method. When the thigh is flexed upon the body, the front half of the capsule, that is, the Y ligament, is never tense. In any other position it is tightly drawn, and from the distance of its attachment from the centre of motion, is not easily overcome, even with the long leverage of the femur. Unless the thigh be flexed, therefore, enormous force is demanded before reduction becomes possible, but when the hip is bent, mobility is restored, and the head slips easily into its socket, often with no more traction than will lift the weight of the limb.

As already stated, this process had been observed many times, and certain procedures for favoring it had been described, but the method had not been able to supplant the pulleys, until by the exhaustive study of Bigelow it was reduced to complete rules, and given to the profession in its present, perfect form.

The present generation did not originate this idea. On the contrary, it is of very great antiquity.

Hippocrates[1] says:—

"In some" dislocations "the thigh is reduced with no preparation, with slight extension, directed by the hands, and with slight movement; and in some the reduction is effected by bending the limb at the joint, and making rotation."

It is not until the year 1676 that we find anything further in this direction, when Richard Wiseman[2] said—

"If the thigh-bone be luxated inward, and the patient young, and of a tender constitution, it may be reduced by the hand of the chirurgeon, viz: he must lay one hand upon the thigh, and the other upon the patient's leg; and having somewhat extended it towards the sound leg, he suddenly must force the knee up towards the belly, and press back the head of the *femur* into its *acetabulum*, and it will knap in; for there is no need of so great extension in this kind of luxation."

In 1713, similar ideas were advanced by Richard Boulton, probably taken from Wiseman.[3] In 1742, three dislocations of the hip-joint were reported as reduced by manipulation by Daniel Turner.[4] He commenced by extending the limb in the old way, and then directed a sudden flexion.

"So soon as the surgeon perceives the bone moving out, let him take his opportunity, giving orders to the extenders below, suddenly to lift up the patient's thigh towards his belly, pressing with his hands either to the right or left, as the situation of the same requires, and therewith force back its head towards the acetabulum whereunto it will . . . . snap sometimes with a loud noise."

In 1772, Thomas Anderson, a surgeon of Leith, Scotland,[5] commenced to practise a method of manipulation strictly in accordance with modern theories, and reported several successful cases. Anderson, not recognizing the action of the ligament, said that he became convinced that the extended position was faulty because of the tension which it produced in the muscles. He averred that by bringing the thigh to nearly a right angle with the trunk, the muscles were relaxed and reduction made easy. He made the necessary extension with the limb bent at the hip-joint. Adducting it, he then drew it with a rotary movement across the opposite limb, thus accomplishing reduction with very little force.

[1] Genuine Works. Sydenham Society's Translation, vol. ii. p. 643.
[2] Eight Chirurgical Treatises. Book VII. chap. viii.
[3] System of Rational and Practical Surgery, p. 346.
[4] Art of Surgery. London, 1742, vol. ii. p. 339.
[5] Medical and Philosophical Commentaries. By a society in Edinburgh. Vol. iii. p. 424, London, 1775.

Pouteau, whose works were edited after his death by Vidal (de Cassis),[1] put on record his opinion that the thigh ought to be flexed to a right angle during the time that extension was made, and rotated when it was believed to be sufficiently extended. This, he thought, relaxed the opposing muscles, which, in his day, were considered the chief agents in resisting reduction.

In 1811, Dr. Physick[2] reduced a dislocation at the hip by flexing the thigh to a right angle and giving the limb a circular sweep, probably much after the manner of Reid, of Rochester. In 1815, Nathan Smith, of the New Haven Medical College, taught that the thigh should be flexed back upon the pelvis and the leg back upon the thigh, and the thigh carried diagonally to the opposite side, whence it was to be swept outward and downward. He also expressed the opinion that the pulleys and other mechanical sources of power were not necessary in reducing dislocations. This he taught for many years, but he does not seem to have published his views. His son, Dr. Nathan R. Smith, of Baltimore, however, explained his father's methods, fully and clearly.[3] In 1820, Dr. Howe, of Boston, a pupil of Nathan Smith, advocated similar methods and used them in his practice.[4]

In the early half of this century more than a dozen different surgeons in various parts of the world reported successes by analogous methods. Yet the literature of the subject was in a very confused and disjointed condition, and attracted little attention at large in the profession.

In 1851, Dr. W. W. Reid, of Rochester, described three cases of dislocation of the head of the femur upon the dorsum of the ilium, and accompanied his paper with so accurate a description of his method that other surgeons were able to repeat the manipulation. This paper attracted great attention, and many of the profession assumed that Dr. Reid was the inventor of the method, so that by some it was termed "Reid's method."

About this time, Prof. Bigelow, of Boston, commenced a course of investigation which was pursued through a series of years, by the aid of careful dissections and experiments upon the cadaver. In 1869 he published his work "The Mechanism of Dislocations and Fractures of the Hip, with the Reduction of Dislocations by the Flexion Method." In this work the whole subject is thoroughly discussed, including the relation of the mechanism of the joint to the movements of manipulation. He placed the whole subject in such system and order that the extension methods soon became obsolete. All the methods of reduction by manipulation are reducible to two, viz. traction and rotation.

(1) *Traction.*—In this method the operator, with a dorsal dislocation, grasps the lower part of the leg in one hand, and flexes the limb both at the knee and hip, nearly to a right angle, at the same time laying the other hand upon the knee to assist in the movement. The thigh is then adducted and slightly rotated inward, using the leverage of the leg to make rotation. This important step, therefore, consists in carrying the knee and the foot in opposite directions—the knee toward the sound limb, the foot away from it. Thus the head of the femur is lifted out from behind the rim of the acetabulum, and at the same time, by the inward rotation of the top of the femur and trochanter, the Y ligament is completely relaxed. The situation is now favorable for easy reduction by very slight traction, only enough force being in general applied to raise the weight of the limb, and to lay the head of the

[1] Œuvres Posthumes de Pouteau. Paris, 1783.
[2] Dorsey's Surgery, 1813, vol. i. p. 242.
[3] Medical and Surgical Memoirs, by Nathan Smith, M.D., edited by N. R. Smith, M.D., p. 163, Baltimore, 1831; Transactions of the New York State Medical Society, 1856, p. 169; Transactions of the New Hampshire State Medical Society, 1854, p. 55.
[4] Boston Medical and Surgical Journal, May, 1840.

bone in its socket, to which the previous manipulations have made the way clear for its entrance. The thigh is now directed nearly perpendicularly to the plane of the body, and is laid somewhat across the sound limb, with the foot drawn outward, away from the median line, by the hand, which grasps the ankle. Let it be remembered that however simple each step of the manipulation may seem, it is absolutely essential to the success of the procedure. If with the limb thus flexed, adducted, and rotated inward, gentle traction now be made, the head of the bone will come into a position directly over the acetabulum, and be ready to glide into its socket. But it is not yet reduced. The rest of the manipulations are as essential to success as any which have preceded them. A false move would throw the head again upon the ilium, but the right one will replace it. To insure this, the movements given the limb are exactly the counterpart of those which have preceded them.

By one rapid movement the surgeon abducts, rotates outward, and extends the limb, or, in other words, carries the knee outward and the foot inward, and lays the limb upon the bed. Reduction is accomplished. The ease with which this takes place is surprisingly in contrast with the enormous force required to reduce a luxated hip by traction in the extended position. Sometimes more resistance is encountered than merely enough to lift the limb, but it is never great. This difference depends mainly upon the size in the rent which has been made through the capsule. Occasionally this is so small as of itself to make some resistance to the head of the bone in its return. In that step of the manipulation, where traction is required, it may be effected by the hand of the surgeon placed behind the knee, drawing gently in the direction of the axis of the femur, or by giving the limb a forcible jerk upward toward the ceiling; or the operator may obtain a still stronger pull upon it by hooking his elbow below the knee. In case the first attempt fails, the manipulation may be repeated, slightly varying the angles of flexion and adduction. The attempt may be repeated several times, and it usually effects a reduction if persisted in, if not at the first attempt.

Where greater traction is required in the estimation of the surgeon, greater force may be obtained by the following plan: Removing his shoe, let him place his foot upon some firm point, such as the anterior superior iliac-spine, or the pubis, to give opportunity for counter-extension, and to steady the pelvis while the traction is being made. The steps of the manipulation are then to be taken precisely as before, except as to the changed position of the surgeon in grasping the limb. Instead of relying upon his hands alone, the operator may employ a jack-towel from the thigh around his shoulders, leaving only the twisting and other movements to the hands, while the pull is exerted by leaning backwards. It is only in rare cases that anything more than the unaided hands is required in the traction method of manipulation. Before resorting to more force, the manipulation should be repeated with thoroughness to make certain that the trouble does not lie in its faulty execution, rather than in the need of more powerful extension.

Every pure dorsal luxation could probably be reduced by the simple method first described, were surgeons not too hasty in giving up the trial. Where it does fail from wrong execution or any cause, it is better not to increase the traction enormously—which would be, in fact, a return to the obsolete methods—but to make use of the other form of manipulation, the rotation method, which will be described presently. This will furnish power enough to reduce the bone with unfailing certainty.

Should it be determined to employ more force in traction, however, this must be obtained without recourse to the pulleys, or any mechanical aid requiring a fixed attachment. These prevent flexion and adduction. A strip

of wood may be passed beneath the calf of the leg, transversely, and held in the hands of two assistants under the surgeon's direction, while he himself grasps the knee and ankle, using the leg as a crank by which to make rotation of the thigh. The limb is thus in very complete and powerful control, and yet at perfect liberty to be submitted to the desired motions. With the pulleys, manipulation is impossible. Another plan by which the same effect may be secured, consists in placing the patient face downward upon a table, with his thighs hanging at right angles to his trunk, over the edge, and with a folded quilt laid under his pelvis. Seizing the ankle of the dislocated limb with one hand, and placing the palm of the other, or the sole of his foot, in the bend of the knee, the surgeon is able to make the usual flexion, adduction, and extension, together with an amount of traction equal to his own weight.

Still more power may be obtained by means of Jarvis's adjuster, which permits the manipulations to be made as usual, together with any amount of traction which the surgeon may deem desirable. This instrument, on account of the movements which it permits, is far superior to the pulleys, but as it is not in the hands of many surgeons at the present time, and will frequently not be attainable in emergencies, or in remote places, some extemporary substitute is needed. For this purpose it is best not to resort to extension from a fixed point, but to make an extemporaneous adjuster, by which the force can be exerted in just the needed directions, which can be quickly changed as desired.

A bar of wood about five feet in length—a bed slat will answer—is to be secured by a notch or hole in one extremity to a large towel or sheet passed about the perineum. This furnishes counter-extension from the pelvis. From the lower part of the thigh, a stout bed-cord, attached by a clove-hitch, passes to the other extremity of the wooden bar, and is attached to a small cleat of wood. By means of twisting the two cords, or, better still, by the Spanish windlass, an enormous degree of traction may be made upon the thigh, while at the same time the limb is under complete control for rotation or other movements. Care must be taken in using either the Jarvis's or the extemporaneous adjuster, that too great force is not exerted unawares. These mechanical aids are seldom needed in the reduction of this form of luxation, and the pulleys never. Let them be considered obsolete in the management of these cases.

The rotation method offers a more certain and less violent means of reducing hip-dislocations, where the traction method fails. One cause of difficulty in the latter, is probably the small size of the rent which has been made in the capsular envelope, resisting the return of the large head of the femur into its socket. In such cases, no manipulation will cause it to return until this rent has been enlarged. The idea of a mechanical rending of the capsule need not appal the surgeon. It is an operation free from danger.

To accomplish this, the thigh should be flexed until it nearly touches the abdomen, when, the pelvis being steadied by an assistant, the knee is carried forcibly outward until the thigh, still sharply flexed, stands outward at a considerable angle from the body. This causes the neck of the femur to sweep laterally across the posterior and lower part of the capsule, tearing its fibres and enlarging the rent made by the head in its exit. Occasionally it occurs that this manipulation effects the reduction. Should this chance to occur, it will be discovered, upon extending the limb preparatory to new attempts. After this manœuvre, the traction method generally will effect reduction with comparative ease by the manipulations already described.

When it has been successful, the limb no longer lies over upon the other, inwardly rotated and stiffly resisting all attempts at abduction and complete

extension, but the popliteal space is down upon the table, the limb is movable in all directions, and the toes turn outward in a natural manner. Grasping the foot, it is found that rotation is possible.

(2) *Rotation Method.*—The method above described is preferable to the other form of manipulation, termed by Bigelow "rotation," because it effects reduction with the least possible injury to the tissues about the joint. Rotation is more violent, but more effective.

The *modus operandi* is as follows: laying one hand upon the knee, to guide its motions, the surgeon grasps the ankle with the other, and flexes the leg upon the thigh, and the thigh upon the abdomen, as far as possible. It is well to have the pelvis steadied by the hands of one or more assistants grasping the alæ of the ilia.

With the limb in this position, let it now be inverted, that is, rotated inward. This causes the head of the bone to ride well away from the back of the ilium, so that it is unlocked from behind the acetabulum. Instead of traction, as in the last method, rotation is now made by sweeping the knee, still kept well down upon the body, transversely outward to an angle of 45° or more. It should be carried outward in this manner to a point where considerable elastic resistance is felt to its further progress. The Y ligament, by this process, is converted into a fulcrum, to make the head of the femur pass inward toward the acetabulum. The last step of the manipulation consists in a quick movement by which the leg is straightened once more in a line with the body. This is done by holding the limb well abducted, carrying the foot and knee downward to full extension, and slightly rotating outward to cause the head of the bone to be thrown inward to its socket. The limb will be seen to be reduced.

It is important that the downward sweep at the close of the manipulation should be forcibly and somewhat suddenly made, the knee being held strongly out by one hand, while the hand upon the ankle gives the rotary motion, the whole being simultaneous. There should be no pause between the outward and the downward sweeps, which for clearness we have described as separate steps. The succession is instantaneous, so that the two steps consist in reality of but one bold movement, beginning with the outward sweep, and passing so suddenly into the downward, that the knee is not observed at any instant to be at a standstill, or "dead point" of motion. Firm and quick handling is essential to the whole manipulation. Too slow or too yielding a touch will allow the head of the bone, at some stage of the manipulation where it is poised ready to re-enter its socket, to slip backward, instead of forward into place.

To assist the memory, the description of the manipulation may be condensed into the following terse directions: *Lift up; bend out; roll out.*

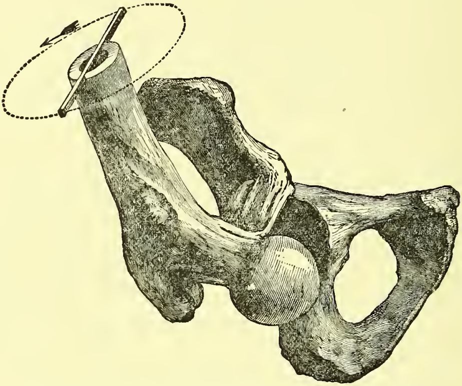
This is the process of hip-reduction once known as "Reid's method." It is very powerful, and has reduced many obstinate dislocations, and some of long standing.

According to Prof. Bigelow, the manipulation will be more certainly successful, if, at the moment when the downward sweep is made, the limb is also jerked sharply upward toward the ceiling. The traction principle would thus be added to that of the rotation method. Upon anatomical grounds the recommendation would seem a good one, but at present it lacks the confirmation of other surgeons' experience.

The energy of the rotation method is very great, and it is usually advisable to first attempt reduction by the milder traction method, reserving the other for obstinate cases. Some idea of its power may be gained from the fact that it has been known to throw the head of the bone beyond its socket, entirely across and through the opposite side of the capsular ligament, so as

to convert the injury into a forward dislocation. I have repeatedly seen this in experimenting upon the cadaver with the rotation method, but not with the traction manipulation, and I do not believe it possible with the latter.

Fig. 568.



Mechanism of reduction of dorsal dislocation by rotation. (Bigelow.)

II. Backward Dislocation Below the Tendon of the Obturator Internus.—The dislocation described by Sir Astley Cooper as occurring directly backward into the sciatic notch, probably does not exist as in any way clearly distinct from other backward dislocations in general. Among these it is true that there are variations in direction and in the amount of displacement, but not differences of kind. Their general symptoms are alike, and their proper treatment identical, and they should therefore be regarded as belonging to a single species in any clinical classification.

On the other hand, when the head of the bone has passed below instead of above the tendon of the obturator internus, a new relation of parts is developed, and new principles of treatment must be invoked, by reason of certain mechanical obstacles which have to be overcome in reduction. These are the luxations which were formerly described as "ischiatic dislocations," and which were believed to be mostly irreducible.

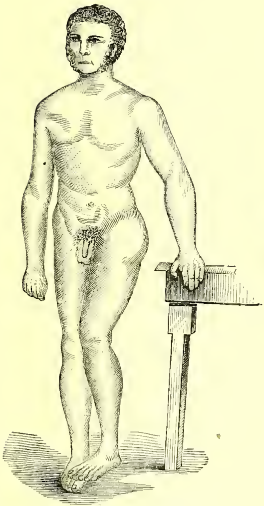
*Causes.*—It is not certainly known from clinical experience what particular form of injury produces the dislocation below, rather than that above the tendon of the obturator. Writers assume that the causes are the same as those which cause the other backward forms of luxation, except that the thigh is more flexed at the time of the injury, and that the direction of the force is more downward, so that the capsule gives way at a point below, instead of above, the tendon of the obturator.

*Symptoms.*—Bigelow says that there is extreme inversion in this luxation, and also an unusual amount of adduction, so that the affected thigh lies across its fellow as high as the middle third. The limb, however, may not be shortened, and may even hang lower than the other, when the patient is in the upright position.

*Pathology.*—As already mentioned, the head of the femur, in this form of luxation, slips below the obturator internus tendon. As soon as the thigh is

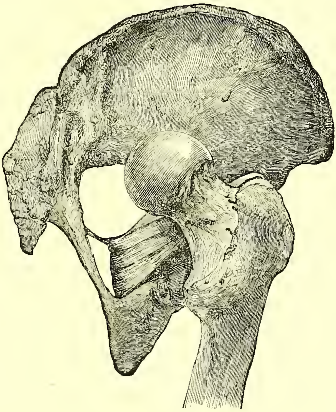
brought down from the bent or flexed position in which the displacement took place, the head of the bone, taking an opposite position by reason of the fulcrum action of the Y ligament, rises upward behind the tendon, which will now wind tightly around the neck of the femur between the head and its socket. It will be seen at once what an insuperable obstacle is here presented to every effort at reduction, unless some special manipulation can enable

Fig. 569.



Dorsal dislocation below the tendon of the obturator internus.

Fig. 570.



Dislocation on dorsum ilii below tendon of obturator internus. (Bigelow.)

the head of the bone to evade the tightly-drawn tendon, and reach its socket without resistance. More exact knowledge of the pathology of this particular form of luxation has taught us how to accomplish this, but it is not surprising that until recent years it should have been considered by the best surgeons as practically irreducible.

*Treatment.*—Traction after Cooper's method should never be employed in this dislocation. When the head and neck of the femur are made to advance toward the acetabulum by simple traction, they are at once arrested by the firm band of the tendon lying between them and their destination. No amount of simple traction can ever suffice to overcome this obstacle, and yet with only slight force, the bone being skilfully guided, all resistance may be avoided, and reduction may be readily secured.

Nor are the principles upon which this is to be accomplished difficult to understand and remember, if an accurate picture of the exact condition of parts be once fixed in the mind. Let the surgeon remember, then, that the tendon lies normally across the back of the joint, a little below its level; that, the thigh being sharply flexed, the head of the bone has burst its eveloping capsule and slipped below the tendon; and that it has gone up behind this

powerful band, which now lies tightly strung across the upper part of the femoral neck.

In attempting the reduction of such a luxation, the surgeon should proceed as follows: With the patient upon his back, the knee is carried across the opposite thigh to a position of extreme adduction, and from thence swept upward, horizontally toward the abdomen, until it is believed that the head of the bone has traversed downward below the tendon. Then the thigh is raised to a vertical position, and the head of the bone will be unlocked from the obturator tendon, and will lie simply in the position of a backward dislocation. Any of the methods already described for the reduction of backward dislocations, will now replace the bone in its socket without unusual difficulty. Thus the *traction* method of manipulation may be tried (see page 686), or the force of the hands may be assisted by a bar passed beneath the bend of the knee, or the patient may be laid face downward with his thighs hanging over the edge of a table, while the surgeon uses his hand or foot to make traction downward. The *rotation* method of manipulation may also be invoked, exactly as in a case of dislocation above the tendon.

Failure will sometimes occur in spite of the best directed efforts, when the head of the femur has gone below the tendon, to disengage it by any manipulation yet discovered. After a thorough trial of the methods which have been described, the imperative necessity of obtaining reduction will justify the employment of no less severe a procedure than the rupturing of the obturator tendon, in order to restore the bones to their normal position. The method of effecting this will next be detailed.

*Manipulation to Rupture the Tendon of the Obturator Internus.*—Recourse may be had to this extreme measure when other means have failed. The severity of the injury inflicted is not great, and by means of it, cases formerly considered hopeless may readily be reduced. On account of the serious nature of the deformity caused by a permanent dislocation, there would seem to be abundant reason for undertaking even a much more severe operation, could success be attained by it. All authorities agree in sanctioning the measure as a last resort. The manipulation consists mainly in circumduction of the limb while in the extended position. Let the femur be adducted and held at the same time flat upon the table or bed, with the thigh kept back at extreme extension. Now let it be swept strongly outward against whatever resistance it may encounter, until the tendon is believed to be torn across. In this movement, the neck of the femur is forced backward and upward directly in opposition to the tense muscle and tendon, and must tear their fibres asunder before it can be pushed far.

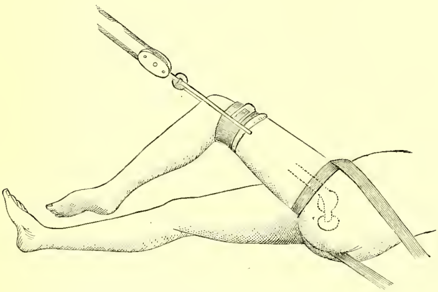
*Older Methods of reducing Backward Dislocations of the Hip.*—The obsolete methods of reducing luxations of the thigh-bone, recommended by Sir Astley Cooper and others, were briefly as follows:—

The patient was first freely bled, to induce a tendency to syncope and relaxation. Nausea was also produced by antimony, and relaxation further favored by placing the patient in hot baths. Although too much importance was then attached to muscular rigidity, and too little to ligamentous resistance, there can be no doubt that the treatment pursued tended greatly to assist reduction, and might even now sometimes be called for, were we not in possession of a far more efficient means of obtaining relaxation, in the induction of anæsthesia.

The patient was next placed upon the operating table, and secured by a strong perineal band passed between the thighs, and carried upward and outward to some staple, ringbolt, or other firm object, for counter-extension

against the extraordinary power about to be called into use for extension. To apply this extension, a damp towel was wrapped about the thigh, just above the knee, and sometimes over this a leather band was buckled, about which in turn was placed the terminal clove hitch of the extension rope. Traction was now made by compound pulleys, in the slightly adducted and flexed position in which the limb is always found. While the traction was thus being made, the surgeon gave to the thigh a rotatory movement both inward and outward, the leg being used, so to speak, as a crank, by grasping it near the ankle while the knee was flexed. After some moments, the tissues usually yielded under the enormous tension of the pulleys. The tension of the untorn side of the capsule no doubt dragged the pelvis into a somewhat

Fig. 571.



Cooper's method of reduction in dorsal dislocation.

more favorable position, some of the resisting fibres yielded or stretched, and the head of the femur gradually approached the socket, until finally it rode over the rim of the joint and snapped suddenly into place. The success attending the employment of the extending bands and pulleys, and the fact that for many years they were in general use, show that they were not as severe in actual practice as might be supposed *a priori*. Upon the old hypothesis, that chiefly muscular resistance needed to be overcome, there was nothing absurd in the use of great traction force. As to the question of ultimate results, few if any recorded cases can be produced to show that recovery was in any way delayed by the force applied. As to the employment, therefore, of Sir Astley Cooper's method, by a modern surgeon, any one will find good surgical authority for the use of the plan, should he choose to try it, and no harm is likely to result to the patient from the experiment; but my own belief is that it never need be employed by any one who has mastered the theory of manipulation.

Some uncertainty attended the use of pulleys, their application in the extended position making the Y ligament very tense, and causing it to exert such an enormous resistance as often to baffle the most skilful surgeons. Sometimes, by the use of a tripod to which the extension was attached in a position vertically above the patient's hips, much better results were obtained.

Jarvis's adjuster added still another facility, for while it was capable of furnishing an enormous amount of traction, it also permitted easy rotation, flexion, and adduction. Even when not best directed, these manipulations commonly assisted much in reduction, partly because they tended to break

resisting bands, and partly because they would often, by mere accident, bring the joint into a more favorable position than that of extension.

This adjuster is a most admirable instrument for producing extension, not only in luxations of the hip, but in all dislocations, especially ancient ones. Making its counter-extension from a point near the axis of motion of the joint, it allows of freest movements in all directions, and will, by this combination of manipulation and strong extension, produce results which the pulleys can never accomplish. Unfortunately, this admirable instrument is no longer manufactured, the modern methods of manipulation having done away with so many of its indications.

Forward Dislocations.—Forward dislocations include under one group all the varieties of displacement in which the head of the femur is thrown into a position anterior to a longitudinal line drawn through the acetabulum. The general distinctions by which these are rendered a separate group from the whole class of backward luxations, arise from the anatomical fact that the trochanter major cannot participate in the forward movement of the head, just as it cannot go back with any of the backward luxations, and for the same reason, viz., the opposition of the Y ligament. The position of the limb is therefore in many respects the direct opposite of that seen in the backward group in general, eversion instead of inversion being a constant symptom; and the movements for effecting reduction are a more or less exact reversal of those which have been already described.

The group of forward dislocations includes the *pubic* luxations, or those directly forward, and the *thyroid*, or those upon the thyroid or obturator foramen.

*General Causes, Symptoms, and Treatment.*—Forward luxations usually occur in accidents where the force is applied to the thigh in full extension, as in falls upon the feet or knee, with the limb straight or bent a little back. Rarely, blows upon the hip have been known to cause this, as they have other forms of luxation. Extreme backward bending of the hip-joint without external violence has been known to produce a pubic dislocation, as in the case of Ure,[1] where the accident occurred in the act of striking out in swimming. Here also the limb must have been widely abducted at the same moment, though the abducted position more commonly causes the thyroid dislocation than the pubic. Sudden separation of the knees, as when a crushing weight falls upon the body, or as when in mounting a horse, or stepping upon a moving object, one foot is carried away from the other, may cause this injury.

The head of the femur is driven through the front of the capsule, inside of the Y ligament, whose traction, assisted by that of the obturator internus, now rolls the shaft of the bone outward, and binds the trochanter against the rim of the acetabulum. The limb will therefore be externally rotated. It is usually abducted, and in the pubic variety commonly shortened; in thyroid dislocations it is lengthened.

The treatment of forward dislocations requires a more or less complete reversal of the manipulations used in the backward forms. It varies somewhat according to the different locations of the femoral head.

III. Dislocation upon the Pubis.—*Causes.*—Extreme extension, or a little backward bending of the thigh at the moment of receiving a sudden blow, or falling upon the feet or knees, has been the cause assigned in most of the few recorded cases of pubic dislocation. It may also be produced by a very

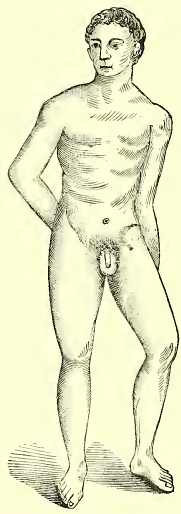
[1] Lancet, Nov. 1857.

violent blow upon the back of the thigh, near its upper end. So slight a cause as a misstep has been known to cause this injury, but is much more likely to cause fracture of the neck of the femur, which often results from a slight fall.

*Pathology.*—The pathology of the pubic variety of dislocation has already been referred to in the general description of forward luxations. The position of the head of the femur varies from a point directly upward, under the Y ligament, to one directly forward upon the body of the pubic bone. Between these two points it may occupy a variety of situations. Sometimes it passes diagonally inward and upward under Poupart's ligament, disturbing more or less the vessels and nerves, but commonly pushing them aside rather than wounding them, and finding a location over and within the pelvic rim under the external oblique and transversalis muscles.

*Symptoms.*—The head of the femur can often be seen to form a large tumor upon the pubis, or wherever it may lie. Most frequently it rides upon the rim of the bone so as to be markedly prominent. The foot lies turned outward, and resists all attempts to give an inward rotation. As in the backward forms of hip-dislocation, there is a marked but not great amount of flexion, which will not yield to pressure, the only effect of pushing the knee downward being to cause an upward arching of the lumbar spine and a tilting of the pelvis forward. Instead of being laid across the opposite limb, the line of the thigh diverges on account of the abduction of the affected member, this being a slightly-marked but constant symptom. Upon the whole, the characteristic features of dislocation rigidly maintain themselves against any efforts at movement, and are resumed when the limb is left free. Upon measurement, the limb is, in most cases, found to be shortened one or two inches, the exceptions being in those cases in which the displacement is directly forward upon the pubis. Measurement also shows that the trochanter major is from half an inch to two and a half inches nearer to the symphysis pubis upon the affected than upon the other side.

Fig. 572.



Pubic dislocation.

A differential *diagnosis* between fracture of the femoral neck and pubic dislocation can always be made, when it is remembered that the outward turning of the fractured thigh is not accompanied by immobility, under an anæsthetic, nor by a flexed and abducted position which will not yield to the hand. The length of the limb can be restored by making traction, in a fracture of the neck, but not in a dislocation. The prominent tumor formed by the head in its new location will settle absolutely the differential diagnosis.

*Treatment of Pubic Dislocations.*—Bigelow recommends the following plans:—

(1) In the forward luxations, as in those backward, the new method involves the necessity of flexion, for the purpose of relaxing the Y ligament; but it is to be remembered that abduction, and not adduction, is the most favorable position for replacement. Proceed by flexing and abducting the thigh—carrying the knee up, and then out, in other words—and make traction in the direction of the axis of the thigh bone, having an assistant, at

the same moment, press the head of the bone downward and outward toward the acetabulum.

A modification of this method, sometimes successful, is as follows: Flex the thigh to a right angle with the body, and rotate the shaft of the bone strongly, either inward or outward, so as to wind up, as it were, the Y ligament upon the femur. With the hand of the surgeon, or of an assistant, pressing strongly upon the head of the bone, swing the limb downward to its place.

(2) The surgeon seats himself at the patient's feet, places one foot in the perineum, making counter-extension against the pubis and ischium, and rotates the limb inward by turning the foot. With his hand, or with a towel around his shoulders, he makes strong traction, and while this is kept up, assistants are ordered to lift the patient's body to a sitting posture.

(3) The patient is laid face downward, his limbs hanging over the padded edge of a table as heretofore described in connection with the treatment of backward luxations, and the knee or foot of the surgeon is placed in the popliteal space to make extension, while the flexed leg of the patient serves as a crank, by which inward rotation is effected. The knee of the affected side is held somewhat away from the other, for the sake of abduction.

(4) The patient is laid upon his back, and the surgeon, stooping over him or kneeling between his abducted thighs, places the dislocated limb so as to flex the knee over his shoulder, embracing the thigh near the pelvis. A large amount of traction can thus be obtained, and the hands can press the head towards the acetabulum.

(5) Circumduction (as in backward dislocations) may be necessary to enlarge the small "button-hole" opening in the capsule, before the head of the femur can be induced to enter its socket.

When, after faithful trial, this seems indicated, sweep the flexed thigh inward, against the fibrous resistance it will encounter, as if intending to convert the pubic into a dorsal dislocation; make strong enough traction, after the circumduction, to raise the patient's hips from the floor, so as to make use of the weight of the trunk for extension. Increased power may be added by making counter-extension with the foot in the perineum, or on the pubis. Sometimes assistance can be rendered by drawing the thigh outward, by means of a band passed around the inner side of the limb.

(6) The method of *rotation*, formerly called Reid's method, varies from that described as fitted for the treatment of backward dislocations, by a reversal of the movements. The limb is first flexed and abducted, then swept around upon the abdomen with the knee bent upon the thigh, the latter being held inverted. The direction of the sweep is toward the median line, or opposite to that employed in the backward form, as already described. When the knee has reached a point immediately above the acetabulum, it is brought directly down to full extension, the thigh being held everted as it comes.

Occasionally this manipulation will convert a pubic into a dorsal dislocation, in which case the latter will have to be reduced by the usual methods.

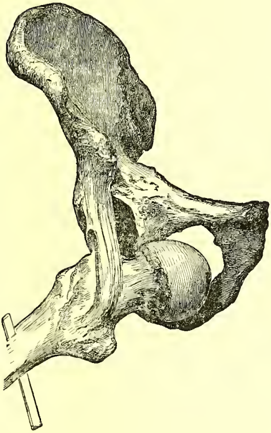
IV. Thyroid Dislocations.—The thyroid dislocation, the last of the four principal varieties, is that form of forward displacement in which the head of the bone takes a downward as well as an anterior direction from its socket.

*Causes.*—Authorities assign as a cause of this injury, violence received while the limb is widely abducted. Although it is often asserted that a blow upon the back, as by a falling object while the thighs are spread, is the usual cause, probably this dislocation occurs most often in falling from a height

and striking obliquely upon the foot or knee, so as to abduct the limb forcibly.

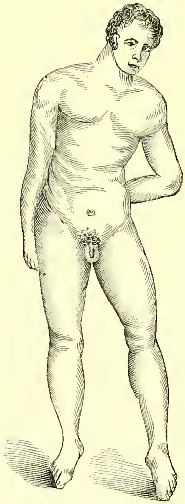
*Pathology.*—The lower, front wall of the capsule gives way, its fibres being rather thin at this point, and the head of the femur slips forward along the horizontal ramus of the pubis to the region of the thyroid foramen, lying sometimes just upon it, sometimes above, and sometimes a little below and behind this opening.

Fig. 573.



Mechanism of dislocation into thyroid foramen, showing the Y-ligament suspending the trochanter. The head of the bone lodged in the thyroid foramen, and the trochanter resting on the acetabulum. (Bigelow.)

Fig. 574.



Thyroid dislocation.

The positions of the head and the trochanter major, in most cases of this variety of luxation, are nearly in the normal plane, so that the neck of the femur points toward the median line, and there is little rotation. When the displacement is more nearly forward, the bone rolls outward to some extent, and when most nearly downward there may even be slight inversion, as in backward dislocation.

*Symptoms.*—Abduction is a constant symptom, and is more marked than in the pubic form of forward dislocation. The foot, as will be inferred from what has been said of the pathological anatomy, does not exhibit a constant tendency to either outward or inward version. Usually it points directly forward, rarely a little inward or outward. In whatever position it lies, it is found to be rigid. As in all the dislocations of the hip, there is some flexion, which cannot be overcome except, seemingly, by tilting the pelvis. This

flexion amounts to about thirty-five degrees. The limb is lengthened by from half an inch to two and one-half inches.

*Treatment.*—The methods of reduction already described for the pubic form of forward dislocation, are equally applicable to thyroid dislocations, with the addition of the following:—

(1) The rotation instead of commencing with abduction (Fig. 575), and sweeping around, as described above for the *rotation* plan in pubic dislocations, may be made in the opposite direction, and with the limb adducted, precisely as in dorsal luxations. Some surgeons prefer this method, and claim for it equal success with the abduction and sweeping toward the body which is most usually advised.

Fig. 575.

Reduction of thyroid dislocation by manipulation. (Bigelow.)

(2) Reduction has often been effected by placing the patient in a sitting posture with his knees straight, and a hassock, roll of blankets, or other broad fulcrum between the upper part of the abducted thighs. The surgeon grasps the two ankles or knees, and presses them toward each other, thus prying the head into its socket by the leverage of the extended thighs.

In principle, many of the methods which have been described for anterior dislocations will be seen to be identical; they have been described independently, for the sake of rendering the instruction more precise and intelligible in each instance.

*Ancient Methods.*—Although mostly obsolete, Cooper's methods call for description, because they were so recently in common use in forward as well as in backward dislocations of the hip. Briefly, they are as follows:—

(1) In *pubic dislocations*, counter-extension was obtained by means of a sheet passed between the thighs, brought together on the outer side of the pelvis on the injured side, and its ends made fast to some firm support. By means of a clove hitch over a towel wrapped around the thigh, just above the knee, traction was made with the pulleys, or Spanish windlass, in a direction downward, that is, with the limb in extension, and a little backward, allowing the limb, for this purpose, to hang somewhat over the edge of the bed or table.

(2) In *thyroid dislocations*, and other forward and downward forms of displacement, reduction was effected by laying the patient horizontally, and passing the counter-extending band about his hips a little below the crest of the ilium, carrying it across the body, back and front, and attaching it to some firm support on the sound side. This band did not pass between the thighs, but surrounded the hip. Next, a band for making extension was passed around the inner side of the dislocated thigh, near its upper extremity, and carried in the opposite direction, outward and a little upward. By means of pulleys this was tightly drawn, with a view of pulling the head of the bone upward and

outward to the acetabulum, while the surgeon grasping the ankle made extension, and used the leverage of the leg and thigh to assist reduction.

Various authors, as the result of experience or of reasoning, suggested modifications of the methods of Sir Astley Cooper, some of which added greatly to the facility of reduction, and were, in fact, steps toward the manipulation methods. These have been alluded to in detail in the historical account of the subject. It has not been the design of this article to describe minutely all the plans of treatment which have been, and might now be, more or less useful in the absence of modern, perfected methods, but rather to give these methods in their most improved forms, as practised at the present day, and the older and obsolete modes by way of contrast, omitting entirely the description of those intermediate varieties, which were, indeed, a vast improvement upon preceding plans, and which served as useful stepping-stones in the transition stage between the old and the new, but which, nevertheless, may now be said to have survived their usefulness.

Irregular or Anomalous Dislocations of the Femur.—In rare instances the Y ligament becomes wholly or partly torn, in dislocations of the hip-joint, so that it does not exert its usual traction upon the neck and trochanter, and the limb does not assume the characteristic attitude as to rotation, flexion, or adduction, by which the diagnosis is ordinarily made.

I. Supra-spinous dislocation (Bigelow) is a form in which the outer branch of the Y ligament is broken, and the head of the bone is lodged above the anterior inferior spinous process of the ilium, with the neck lying across the rim of the pelvis, and the trochanter turned backward so as to rotate the shaft externally. Of course the eversion and shortening are very great. There is also some abduction, and the limb as usual is rigidly fixed, partly by the inner, untorn branch of the ligament, and partly because the head of the bone is hooked over the rim of the pelvis.

*Treatment* should be directed toward unhooking the femoral neck from the untorn part of the ligament, by sweeping the knee inward into the adducted position, at the same time rotating the femur outward until the head of the bone comes down upon the dorsum of the ilium, when reduction may be affected as in other dorsal dislocations.

II. Everted dorsal dislocations are said by various authors to have occurred. Ordinarily, the backward forms of luxation are accompanied by great inward rotation, or inversion, on account of the tension of the untorn Y ligament holding the trochanter forward as the head of the bone goes back. In the rare cases here referred to, the trochanter goes backwards with the femoral head, and lies behind it. Such a displacement could only occur where there had been free laceration of the external branch of the ligament, releasing the trochanter from its restraint.

The *treatment* is not materially different from that of the usual dorsal form, except that it must always begin by flexing, adducting, and inverting the thigh, before other manipulations are made.

III. Other rare forms occur in which the Y ligament is completely sundered, together with other portions of the capsule. The retaining bands, which usually give distinctive positions to the displaced bone in the various dislocations, are wholly broken away in these cases, and no definite characteristics can be assigned them. Luxations of this kind are very rarely seen. Their *treatment* should be mostly by traction in whatever direction the limb most easily assumes, and with whatever manipulation each case calls for.

There will be much variation in these respects, according to the varying mechanism of the several injuries.

Dislocations of the Hip Complicated by Fracture.—Fractures of the shaft of the femur, accompanying any form of dislocation, greatly embarrass the process of reduction, as they deprive us of the leverage of the shaft in manipulation. Traction, however, may be employed efficaciously, and in several directions, unless the fracture be in close proximity to the joint. With the pubic dislocation, direct pressure upon the bone assists much in reduction. A probability of success attends patient trials even in these difficult cases. Should, however, all efforts fail, the alternative is presented either of leaving the luxation unreduced until union has occurred, and then treating the case as one of ancient dislocation, or of making a subcutaneous section of the outer side of the Y ligament with the tenotome, in accordance with the practice recommended in dislocations of the elbow and other joints, rather than leave the bone unreduced. Under antiseptics, the operation is no more dangerous than the same amount of injury to the soft parts by simple tearing. I have frequently divided in this manner the resisting bands of old dislocations of other joints, and have thus accomplished reduction which was impossible by ordinary means, without causing the slightest unfavorable reaction, and without ever seeing bad results follow. For dividing the Y ligament at its most resisting part, the tenotome should be entered over the prominence of the trochanter, carrying it deeply inward and giving it a curved sweep from before backward, so as to graze the upper margin of the bone.

Instead of section of the ligament, an incision may be made below the trochanter, down to the bone on its outer side, and the shaft may then be seized with lion-jawed forceps, while assistants hold the limb vertically and make strong extension, and so manipulated as to effect reduction; after which, proper extension for the fracture, and proper dressings for the wound, may be applied as usual. In spite of their severity, these measures, in my opinion, are warranted by the extremity of the case.

Voluntary Dislocations of the Hip.—Of late years, several persons with abnormally lax joints have excited the interest of physicians and medical students, by their extraordinary power of changing the shape of their joints, so as to make them appear the seat of dislocation. These are cases of congenital peculiarity, in which several members of the same family are similarly constituted. One man in Chicago has so cultivated his power of displacing the bones, that he can at will produce nearly perfect dislocations of most of the synovial joints. His joints have always been very movable, and by cultivating the action of certain muscles he has attained the power of slipping the articulating surfaces of such joints as the hip and knee, in any direction at will. This laxity of his joint-capsules does not in any way interfere with his bodily strength or power of limb. He is, on the contrary, a man of great physical strength, and of unusual skill in gymnastic feats requiring steadiness and precision.

Ancient Dislocations of the Hip.—It was the opinion of Sir Astley Cooper that the shoulder-joint became so fixed in three months after dislocation, and the hip-joint in eight weeks, that it was in most cases imprudent to make any powerful attempt at reduction after those periods. I believe, however, that reduction can nearly always be accomplished even after a longer time. Much caution and patience, and a certain degree of boldness, where experience has shown that we may proceed safely, are requisite in the handling of these cases. On the one hand, greater force and greater persist-

ence are requisite than in recent dislocations, and, on the other, it must be remembered that there is danger, from the adhesion of the head of the bone in its new location, of rupturing important vessels or other organs in using great force.

My own practice, in most difficult cases of ancient dislocation, is to make a subcutaneous, antiseptic division of the more or less resisting ligamentous tissues, using the instruments and plan of operation commonly employed in tenotomy. Of course, the tenotome should never be employed until after a thorough trial of the more common methods.

This mode of operative interference has not been indisputably proved to be the best for obtaining reduction in dislocations of any of the larger joints, since the literature of surgery does not furnish actual statistics sufficient for the purpose. I believe it to be justifiable, however, in the case of almost every joint in the body, as a common-sense deduction from what is known of the pathology of dislocations. Should there be any difference, it would be in the case of the larger joints, such as the hip, knee, and ankle, where the lighting up of suppurative synovitis might lead to fatal results. Without antiseptics, such an operation upon any of the larger joints should not for a moment be thought of.

## Dislocations of the Patella.

Outward Dislocation of the Patella.—*Causes.*—This luxation is occasioned either by external force, or by muscular action exerted in peculiar conditions. The patella may also be displaced laterally, as a sequence of caries of the condyles of the femur, when the disease destroys the ridge which retains the patella on one or the other side.

*Symptoms.*—If the dislocation be complete, the patella will be found lying on the outer slope of the condyle, with its inner border forwards; but if incomplete, the form of the articular surfaces is such that the patella will be tilted somewhat edgewise, with its outer border projecting forward. The knee is slightly bent, and immovable, and the patella may be felt in its new position. The pain is generally pretty severe. After reduction, the dislocation is liable to be reproduced from slight causes.

*Treatment.*—In order to effect reduction, it is best first to relax the quadriceps extensor by flexing the thigh on the body, and extending the leg on the thigh. When this is done, the bone can usually be replaced by lateral pressure of the thumbs. If reduction prove difficult, it will be necessary to anæsthetize the patient, and then to dislodge the patella by vigorous flexion and extension of the knee, and afterwards proceed again as before.

Inward Dislocation of the Patella.—*Causes.*—This accident generally results from external force applied directly to the outer margin of the patella.

*Symptoms and Treatment.*—These are the same as in the outward dislocation, except that the direction of the displacement, and that of the pressure required for reduction, are reversed.

Dislocation of the Patella on its Axis.—In a few rare cases, the patella is completely overturned, presenting its posterior surface forward. In other instances it stops half-way, one margin being sunk in the outer condyloid fossa, while the other stands sharply forward, presenting a prominence beneath the skin which cannot be mistaken. In a case of complete overturning, the sharp margin of the articular surface, presenting outward, can be felt and

readily distinguished from the more rounded surface of the patella in its proper position.

*Treatment.*—In case of partial dislocation of the patella upon its axis, so that the bone stands upon one edge, the patient, after being anæsthetized to relax the quadriceps, should be placed with the leg in full extension, and efforts made to effect reduction with the hands. In case of failure, the knee should be forcibly bent and suddenly straightened, in order to loosen the bone from its impaction between the condyles, and then efforts should be repeated to bring it into proper position. If the head of a key, or some smooth object, be pressed in against the lower edge, while the hand pushes forcibly in the opposite direction against the projecting upper border, considerable advantage sometimes will be gained. In case of complete dislocation, reduction may be accomplished upon the same principles. Ascertain the direction of the torsion by examining the two edges of the patella, with the knee fully extended and the thigh somewhat raised, so as to relax the quadriceps. Then, by grasping and pushing one or other, or both, sides of the bone, as before, it may commonly be replaced without much trouble.

Should these manipulations prove unsuccessful, the surgeon would be justified in seizing the bone in the jaws of a pair of sharp-toothed forceps (like lion-jawed forceps, but more slender-toothed), and by the aid of these turning over the patella. Careful antiseptic precautions must be observed in this operation, since there is great liability for the points of one or more of the teeth of the forceps to enter the cavity of the capsule. Some authors recommend that the ligamentum patellæ should be divided, and also the insertion of the extensor tendon, in order to facilitate the reduction in difficult cases. The operation has not met with much favor on account of the risk of suppurative synovitis to which it subjects the patient. One case is recorded in which this occurred and proved fatal. Dr. J. B. Roberts, in his notes to Bryant's Surgery, advocates the operation.

## Dislocations of the Knee-joint.

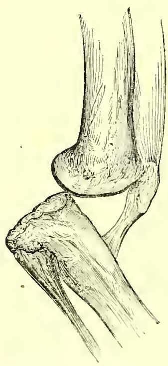
Considering the great exposure of the knee to blows and other forms of violence, its dislocations are quite rare; in the vast majority of cases, the thigh or the leg will be fractured before the knee will yield. This immunity is not due to any peculiarity of the bony conformation, as in the case of the vertebræ, where fracture must nearly always take place before the bones can be disjointed, but to the uncommon size of the articulation and to its powerful ligaments. The existence of the crucial ligaments in the interior of the joint, and the great thickening of the capsule which at each side forms the lateral ligament, are the most important factors in resisting displacement. In describing dislocations, we speak of the lower bone as the one luxated. The tibia may then be dislocated upon the femur, either *backward*, *forward*, *inward*, or *outward*.

Backward Dislocation of the Tibia.—*Causes.*—Direct violence in the region of the knee is the usual cause of this injury.

*Symptoms.*—The head of the tibia is found, upon examination, to be driven back toward the popliteal space, where it may be felt by the hand. In front, there is a corresponding vacuity, and a depression immediately below the patella, on either side of the ligamentum patellæ. The amount of shortening is not uniform. Usually, the leg is extremely extended, and the line of the tibia slopes forward, forming an obtuse angle with that of the femur. The ligaments are more or less torn, according to the extent of the displacement,

and this has much to do with the prognosis. Anchylosis sometimes occurs here, as in other joints, when synovitis sets in after reduction. Usually, however, after replacement, a good recovery of all the original functions may be predicted. When the luxation is not reduced, there remains great imperfection of the limb, but in many cases more mobility and strength for walking exist than would naturally be anticipated.

Fig. 576.



Backward dislocation of the tibia.

*Treatment.*—In a certain number of cases, where the dislocation is not quite complete, it may often be reduced by manipulation alone without resorting to extension. For this purpose the patient may be laid upon his back, with a cushion under the calf of the leg, but not extending above the knee, thus leaving a vacant space beneath the lower portion of the thigh. Direct efforts are now to be made by the hands of assistants to press the femur backward, while the joint is rocked backward and forward, and occasionally laterally, to facilitate replacement. Failing in this, Hamilton recommends that the limb should be forcibly flexed, and then extended still further, in order to free it from resisting fibres, and that then reduction by pressure on the femur should again be tried. Alternate flexion and extension may in this way be tried several times, when, if reduction be not accomplished, extension and counter-extension by means of pulleys or other apparatus, or simply by the hands of two assistants, may be invoked to assist the reduction, the surgeon continuing the manipulations already described.

Dislocation of the Head of the Tibia Forward.—In this injury, the tibia is found to be projected forward upon the condyles of the femur, which are correspondingly projected backward, bulging into the popliteal space. The important vessels and nerves of this region are frequently so pressed upon as to cause numbness and absence of pulsation below; and occasionally rupture of the popliteal artery may give rise to extravasation or traumatic aneurism.

*Treatment.*—Reduction may be accomplished in essentially the same manner as in backward dislocation, except that the forced flexion there recommended should not be employed. If pressure alone will not effect replacement, and extension seem called for, as is often the case, the latter may be applied by the hands of assistants, or by pulleys, with perineal bands for counter-extension, the surgeon, by preference, keeping his own hands free to conduct the necessary manipulations.

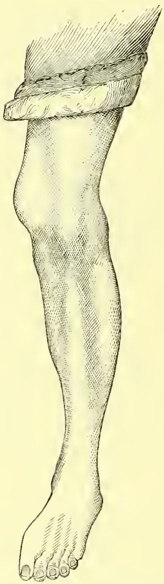
Lateral Dislocations of the Head of the Tibia.—The lateral dislocations are usually incomplete. In displacement of the head of the tibia *outward*, there is considerable lateral movement, but not complete separation of the joint surfaces. The articular facet which normally supports the inner condyle of the femur is carried outward, and rests under the external condyle, while the external facet of the tibia is carried out still further. As regards pathology and symptoms, the *inward* luxation is similar to the outward, except for a reversal of the direction of displacement.

The external appearance of the knee shows the prominence of the femur and the tibia upon opposite sides. There is no shortening of the limb, but

considerable immobility. No difficulty is experienced in determining the nature of the injury upon inspection and palpation.

Complete lateral dislocations at the knee are of very rare occurrence. When from extraordinary violence they do occur, the extreme tension frequently causes the head of the bone to rend its way through the skin, causing a compound dislocation.

Fig. 577.



Incomplete, outward dislocation of tibia.

*Treatment.*—Incomplete lateral dislocations may be reduced by laying the patient upon his side, placing a firm cushion or pad beneath the projecting bone, and pressing the other bone down to its proper position. This pad may be put under either the upper or the lower bone. If any difficulty be experienced in this method, extension may be employed in addition to compression, and the replacement facilitated by giving to the two bones a rocking motion upon each other.

*Oblique dislocations of the knee* are said to occur, in which the head of the tibia takes a direction backward as well as outward. These cases are rarely met with. They are to be treated upon the principles already laid down.

Compound Dislocation of the Knee-Joint.—This is an accident of not very rare occurrence, and of very grave importance. It has been the opinion of surgeons hitherto, owing to the very great fatality caused by the violent suppurative inflammation which is almost sure to follow conservative treatment, that primary amputation, or excision, is the obvious indication. In the case of a laboring man, or of any person unable to give up his employment a long time, and to obtain careful attention during a tedious confinement of months' duration, amputation has seemed to offer the best, safest, and quickest prospect of recovery, and, for practical purposes, a limb nearly as useful as any that could be obtained otherwise.

Persons who could obtain careful attention in good surroundings, who preferred the natural, though mutilated, limb to any artificial appliance, and who were also willing for the sake of this to undergo a somewhat greater risk of life, could have the knee-joint excected, and recover ultimately with a motionless knee, but with the natural leg in place. The one other course—conservatism without excision—was under old methods so uniformly the cause of death from pyæmia and exhaustion, that it found no favor with surgical writers.

This opinion has not as yet been controverted, nor can it successfully be overturned on the basis of our present experience, for want of new statistics; but it nevertheless may be true that the introduction of the antiseptic method offers a means of saving the joint, and even of restoring its function, in some cases, with far less serious risk to life than any previous plan of treatment. We cannot, from the meagre statistics which we now possess, make a thoroughly scientific induction as to the prospects of this method of treatment without operation; but enough is known to render it perfectly justifiable for the surgeon to make an attempt to save the limb.

In carrying out such a plan, the utmost thoroughness is obligatory, and the openings for drainage must be made, and other details attended to, in accordance with a well-considered plan of local treatment, which involves considerable care and watchfulness.

Full instructions will be found on another page for making the six openings into the knee-joint, commonly used by the author, so as to obtain thorough access for drainage-tubes and for injections, to every square inch of its synovial lining. As the area of the joint surfaces in the knee far exceeds that of any other articulation, so does the severity of the reaction, when it is inflamed, while the necessity for efficient management in the local treatment is correspondingly increased.

In addition to the carbolized injections and antiseptic dressings, frequently renewed ice-bags of large size are to be applied to meet the first invasion of inflammatory symptoms, and to maintain a thorough, antiphlogistic influence. In this manner there will be hope of carrying the patient through a tedious convalescence, without great risk to life. Anchylosis very commonly but not invariably results. When this is considered inevitable, the limb should be placed in a slightly bent position, as this is found to be more favorable for locomotion and general comfort than that of full extension.

Minor Displacements of the Knee.—The peculiar structure of this joint, having a rim of fibro-cartilage forming a wedge-shaped layer around its circumference, leads to several minor accidents whose precise nature is often obscure. Injuries of this kind receive from different surgeons various names. Hamilton avoids the question of exact pathology, by classing all under the group of "*Internal derangements of the knee-joint.*" Erichsen denominates them "*Subluxations of the knee.*" Sir Astley Cooper regarded them as partial dislocations of the femur from the semilunar cartilages, and Malgaigne believed them to be subluxations of the latter cartilages from the tibia.

In all probability, a variety of different injuries occur within the knee, but as they lack the confirmation of post-mortem study, and as their external symptoms are slight, it is probable that the exact pathology of these injuries will remain in doubt. "Floating" or "loose" cartilages in the knee-joint are discussed in another article. Sudden strains in a rotary direction are said to be the cause of most of these internal displacements.

The symptoms are a sudden locking and violent pain in the region of the joint, often while walking. The patient is compelled to cease instantly all efforts at flexion or extension, and sometimes is thrown to the ground by his sudden inability to make the necessary movements to preserve his balance.

The treatment of these injuries consists in gentle manipulation. The reduction usually takes place after a little handling, without the patient or surgeon being able to say just what change in the relation of parts has occurred. If gentle movements, and pressure at different points, do not result in restoring to the joint a normal state of feeling and mobility, the patient may be anæsthetized, and the limb strongly flexed and extended alternately, when its natural condition will soon be restored.

It is said that portions of the semilunar cartilages are sometimes broken loose, and driven into the interior of the joint. If such an injury should occur, its nature might be discovered by the touch of the finger, and reduction might perhaps be effected by rocking movements of the joint in various directions, so as to make the condyles of the femur act as wedges, and force the loose piece out to its place.

Dislocation of the Head of the Fibula.—This is a rare accident which Bryant attributes in most instances to violent adduction of the foot and abduction of the knee.

The *diagnosis* is made by an examination of the relative positions of the heads of the fibulæ upon the two limbs. On the dislocated side, the bone is carried outward, and sometimes forward or backward from its usual situation, and is very readily felt and seen to be out of place.

*Reduction* is accomplished by making firm pressure of the thumbs upon the tumor caused by the displaced head. After reduction, a compress should be placed directly outside of the joint, and should be worn for several weeks in order to prevent redisplacement.

## Dislocations of the Ankle-joint.

Some confusion in the terminology of ankle dislocations has resulted because certain authors, such as Cooper, Malgaigne, and Hamilton, have described them as displacements of the lower end of the tibia, while others, such as Boyer, Ashhurst, and Bryant, have classed them as luxations of the foot from the tibia, preferring to regard the distal as that which is displaced upon the proximal bone, in accordance with the method of classification pursued in other parts of the body. Analogy would, therefore, lead us to regard the astragalus and not the tibia as the dislocated bone, although, in the strictest sense, all dislocations are, of course, a mutual separation of parts. Some considerations, however, have caused a number of modern surgeons to take the opposite view. Thus, in walking, the foot becomes a fixed base of support, and a dislocation, if it takes place, may be considered as a displacement of the moving tibia, especially since the articulating surface of the latter is so much smaller than the tarsus. The mind more readily conceives of the smaller organ being displaced upon the larger, than of the larger being carried away from the smaller. This question of nomenclature has no bearing upon pathology or treatment, but it is important to use such language as may explain itself at each step, and leave no ambiguity.

I prefer to regard the distal part as that which undergoes displacement.

Dislocations, then, of the tarsus upon the leg may be in four directions, viz., *forward*, *backward*, *inward*, and *outward*. Each of these dislocations is accompanied, in most cases, by a fracture of the fibula, a short distance above the joint.

Lateral Dislocations of the Tarsus.—The dislocations inward and outward are usually incomplete, and, in fact, are to be considered rather as rotations within the joint, than as displacements of the astragalus from the tibia.

*Causes.*—This injury is frequently produced by falling so as to strike upon the foot, with the ankle turned over. The weight of the body, suddenly arrested, gives the joint a violent wrench, turning the foot over into the position of *varus* or *valgus*, so that its inner or outer border rests upon the ground. The fibula is broken as already mentioned.

*Symptoms.*—Usually, fracture of the fibula accompanies the lateral as well as the other luxations. Sometimes also the internal malleolus is broken. The inner or outer surface of the astragalus lies upon the articular extremity of the tibia, in most cases, but sometimes there is a true lateral displacement, in which case there is not so much rotation or turning of the foot. Complete lateral displacements are generally compound, a form of injury attended with great fatality.

*Treatment.*—In the slighter forms of lateral dislocation, the patient, or some bystander, not infrequently reduces the dislocation upon first observing it, simply by drawing the foot around into its true position with the hand. When

found still turned over, the foot may be reduced by making extension, or by carrying it around toward the axis of the limb, after which the fracture of the malleolus, which commonly but not invariably has occurred, is to be properly adjusted, and dressed with splints or plaster. The broken end of the fibula is sometimes very thoroughly separated from its shaft, and I have seen it completely overset, and presenting its ragged, broken edge outward and downward, even when the foot was replaced. Care should be taken that this loose fragment be set nicely into its old position. An anæsthetic is usually necessary.

In the more complete forms of displacement, very powerful traction may be required. Jarvis's adjuster, or pulleys, may be employed for this purpose. The patient being laid upon his back, the thigh is flexed upon the trunk and the knee sharply bent, to obtain muscular relaxation. Counter-extension is best secured by means of a band around the thigh, just above the knee, passing thence to some firm support, should pulleys have to be resorted to. A loop of cloth around the ankle furnishes attachment to the extending bands. The bent position relaxes the gastrocnemius muscle, and deprives the tendo Achillis of much of its power of resistance. As the extension is gradually applied by assistants, the surgeon employs his hands in making pressure upon the tibia and foot in such directions as tend to bring the bones together.

Rest in bed will usually be required in the after-treatment of these cases, even where no fracture of the malleolus is present. Bavarian plaster-dressings are of excellent service in cases where a fracture complicates the luxation.

Backward Dislocation of the Tarsus.—Backward luxation of the foot upon the leg, sometimes called "*Dislocation of the lower end of the tibia and fibula forward upon the foot*," is of particular interest on account of the difficulties in the way of its reduction, the embarrassments encountered in maintaining the bones in position, and the malpractice suits which have resulted from the maimed condition in which the foot is often left.

*Causes.*—The producing cause must be found in some extreme violence exerted in the direction of the shaft of the tibia, when the foot is fixed upon the ground; hence falls, in which the patient strikes upon the feet, are the most common causes of this injury.

*Pathology.*—The great tendency to redisplacement met with in this dislocation, was not satisfactorily understood until Professor Jarjavay, of the Hôpital Beaujon, of Paris, demonstrated by a large number of dissections the existence of a fracture of the posterior rim of the articulation. The posterior ligaments, instead of being ruptured, were still intact in nearly all of these cases, and strongly united to the posterior lip of the joint cavity. The latter still retained its normal position in relation to the foot, having been separated from the rest of the bone by a fracture running obliquely upward and backward.

By reference to the annexed cut (Fig. 578), it may be readily seen that the removal of this posterior lip reduces the tibia at its lower end to a single inclined plane, which renders it extremely easy for the foot to slip backward, or, as some prefer to say, for the tibia to slip forward upon the foot.

Upon the smoothly rounded astragalus, the position of this broken joint surface, when reduced, is one of extremely unstable equilibrium, so that muscular contraction inevitably causes recurrence of displacement when extension is relaxed. It is said that Malgaigne made such strenuous attempts to retain the foot in place that, in one or more instances, he sacrificed the life of the patient by over-zealous efforts. His results, however, were no more commendable than those of other surgeons less energetic in their methods. The fibula is usually fractured in these, as in the lateral dislocations.

*Symptoms.*—External inspection shows the foot to have gone back, and a little up, from its true position. If the patient be laid horizontally, with the leg upon a plane surface, it will be seen that the tibia is more advanced than usual; it lies in front, over the instep, presenting a great prominence which can hardly be mistaken, unless concealed by great œdema of the tissues in front. The heel, in other words, projects much too far backward, and the foot in front is too short. To the hand, if not to the eye, the prominence of the lower end of the tibia is very perceptible, and the tendo Achillis is drawn backward into a greater curve than its fellow.

Fig. 578.

Backward dislocation of tarsus.

*Treatment.*—Reduction may be accomplished by placing the limb in a flexed position, and making traction upon the foot by the hands of assistants, or by the pulleys, while the surgeon pushes forward upon the heel and backward upon the front of the leg. Merely to reduce the luxation, is usually not difficult; to prevent redisplacement, is in nearly every case impossible. There will be some variation as to the tendency of the bone to escape, dependent on the greater or less approximation to a single inclined plane of the lower end of the tibia, by reason of the fracture of the posterior lip of the joint. As the fractured portion is out of the reach of any external manipulation, it is not always easy to elicit crepitus, and the surgeon is often obliged to infer the condition from the presence or absence of a tendency to reluxation. Great care in the after-treatment is obligatory in these cases.

The limb should be dressed upon a double-inclined plane to relax the gastrocnemius, and the foot kept at a right angle to the leg, with suitable bandages, and with splints of wood, leather, or plaster of Paris, adapted to the shape of the limb in such a way as, by firm pressure, to retain the parts in position. The most efficient application is undoubtedly the plaster-dressing, but it is also one the use of which requires caution, on account of the danger of compressing and stopping the circulation in the limb. The plaster-roller is especially objectionable on this score, since it cannot be relaxed if swelling occurs, without destroying it entirely. The best plan is to use about four layers of Canton flannel or crash towelling, with plaster spread between, wrapping these about the limb from the bend of the knee to the toes, and leaving a line of separation along the front, so that the splint may, at any time, be "sprung" open and taken off without injuring it for further use. The cloth layers should first be cut to wrap properly about the limb, and, when the dressing is applied, an ordinary roller is used to keep it in place. Merely loosening or tightening this roller controls the tightness of the dressing. With this splint, the limb may be examined daily, and still held with all the security which plaster-dressings afford against displacement. The constant tendency to reluxation will have to be met as the ingenuity of the surgeon suggests, by means of various pads and supplementary bandages. At best, success will be indifferent. All hope of permanent retention rests upon the possibility of securing a union of the fractured, posterior rim with the shaft. As perfect coaptation is probably impossible, this seems rarely to occur, and very great permanent deformity is the rule. Still, every effort is to be made in the direction indicated, and greater success will doubtless attend the more extensive use of plaster-dressings than has heretofore been obtained.

Forward Dislocation of the Tarsus.—This is the *backward dislocation of the tibia on the foot*, of many authors. The *causes* of this rare injury are similar to those of the backward form just described.

Applying the same tests as in the latter case, the *symptoms* are of an opposite kind, that is, the line of the tibia is too far back, the foot projects too much in front, the heel seems not at all prominent, and the end of the tibia is felt, if not seen, back of its proper position. Not only is the fibula generally found to be broken, but in most of the recorded cases the internal malleolus, as well, has been described as fractured. The bony conformation of the ankle-joint is such that dislocation can rarely occur without a fracture of one or both malleoli, or of some part of the articulating surface of the tibia, whence the fact that the leg or thigh bones so much more frequently suffer than the ankle, in severe falls upon the feet.

Fig. 579.

Forward dislocation of the tarsus.

*Treatment.*—Reduction is effected as in the backward displacement of the tarsus. After replacement, a tendency to relaxation is not mentioned in the records as being troublesome, doubtless because the rim of the joint is not broken away as in the posterior dislocation. Plaster dressings are a valuable means in this injury of securing immobility and good apposition of the small broken extremities of the tibia and fibula. The rarity of the accident makes generalization uncertain as to *prognosis*, but this apparently is favorable in regard to ultimate recovery of full use of the foot. Dressings are to be worn for about six weeks from the time of injury, when the fractures will generally have become united. Passive movements may be begun much earlier than this, to prevent too much stiffening of the joint from mere disuse.

Dislocation of the Inferior Extremity of the Fibula.—Only one example of this injury, in its simple form, is well attested. This is Nélaton's case, which is said to have been produced by a carriage-wheel passing across the ankle, or just above it, so as to force the lower end of the fibula backward, until it rested in contact with the tendo Achillis. The external face of the astragalus was distinctly perceptible at the usual location of the external malleolus, but the foot was in natural position, very strangely, not being inverted. The case was first seen six weeks after the injury, at which time the patient could with careful steps walk for a considerable distance.

The dislocation was pronounced incurable on account of the length of time which had elapsed.

The literature of the profession therefore furnishes no account of *treatment* in these cases. It is rational to suppose that this dislocation might have been reduced by pressure upon the bone from behind, with perhaps subcutaneous section with a tenotome of some resisting bands.

Compound Dislocation of the Ankle-Joint.—In cases of severe fall, it is not very rare for the lower end of the tibia or fibula to be driven through the integument, so as to lay open the ankle-joint to the external air. Com-

pound dislocations of the ankle are accidents of extreme gravity, as is well shown by the number of fatal cases which are on record.

In deciding upon the course of *treatment*, we are to be guided to a certain extent by the statistics of the various plans which have been adopted. It is the danger to life, rather than the question of usefulness, which must chiefly guide us in determining what method to pursue.

As to pure *conservation*, the majority of cases in which simple reduction has been practised, have resulted disastrously by suppuration and caries, leading to pyæmia. Hence the precept has become pretty firmly established that primary *amputation* or *excision* should be performed. The perfection of antiseptic surgery has raised anew the question as to whether by very thorough drainage, with several large openings and daily, carbolized injections, conservative treatment might not be more successful, but this question is as yet not settled. I am inclined to believe in the future success of this method, but it certainly cannot now be unhesitatingly recommended, from lack of experience. We could not usually expect from this conservative, antiseptic treatment much better results than from excision, since the joint would in most cases become anchylosed; hence, unless much safer, the method would have little to recommend it.

A choice of four methods of operation may be made in compound dislocations of the ankle-joint. These are :—

(1) Syme's amputation,
(2) Pirogoff's amputation,
(3) Amputation at the lower third of the leg,
(4) Excision.

The relative dangers of these operations may best be shown by introducing here the following table of cases from the author's work on the mortality of surgical operations, and from Dr. Culbertson's well-known monograph.[1]

| Operation. | Cases. | Died. | Mortality per cent. |
|---|---|---|---|
| Syme's amputation . . . . . . . | 325 | 30 | 9 |
| Pirogoff's amputation . . . . . . . | 130 | 24 | 18 |
| Amputation at lower third of leg (traumatic) . | 148 | 48 | 32 |
| Excision of ankle (exclusive of gunshot wounds) | 152 | 19 | 12 |

Of these operations, it will be seen that Syme's amputation is the first, and excision the next, in order of safety. The latter preserves the foot in such a perfect condition that many prefer it, as I do myself, in spite of the apparent, slightly-increased danger.

In point both of danger and of injury to the limb, the amputation at the lower third of the leg is the most objectionable of all, and ought never to be resorted to, save where there is great destruction of the tissues below. In ordinary practice, the percentage of mortality will be found less than in the above statistics, which include a large number of cases from the hospitals of Vienna and Paris, where a fearful mortality accompanies all surgical operations.

## Dislocations of the Bones of the Foot.

Dislocation of the Astragalus.—As distinguished from dislocation of the whole tarsus, this is said to occur when the astragalus is driven both from its tarsal and from its tibial articulation. By Malgaigne, this was termed a double dislocation. The displacement may be forward, backward, inward,

[1] Transactions of the American Medical Association, 1876. Supplement.

or outward, as well as diagonally between these directions. Occasionally, the astragalus is said to have been revolved partially upon its own axis, without much lateral movement, and even to have been driven upward between the bones of the leg.

The *causes* are nearly the same as those which produce dislocations of the whole tarsus.

The injury is *diagnosed* by observing that the foot is twisted to one side or the other, or very strongly flexed or extended, and that the astragalus forms a projecting tumor under the skin, in one or other location, as above stated. The tibia sinks down upon the os calcis, shortening the limb and causing the malleoli to approach the sole of the foot. In backward displacement, the tibia is forced somewhat forward, and the case resembles a backward dislocation of the tarsus. Sometimes from the stretching of the integument over the astragalus in its new position, the skin is ruptured, and the dislocation becomes compound, and from the great swelling and tension mortification may result.

*Reduction* is readily brought about, and recovery is prompt if the circulation is not impaired. Compound dislocations are to be treated as other compound dislocations at the ankle. To effect reduction, the patient, after being anæsthetized, should have the knee flexed to a right angle, and the thigh held vertically, as already described, counter-extension being made at the lower third of the thigh, and extension upon the foot by the hands of an assistant, while the surgeon tries, by forcing with the palms of his hands, to push the bones into place. Failing in this manner, the extending force must be increased by mechanical aids, such as the Jarvis's adjuster, or pulleys. Where even this fails, the foot may be rocked to and fro during extension, to facilitate the surgeon's efforts to insinuate the bone into its proper position. Hamilton advises that oblique dislocations should, if possible, be reduced first to those of the anterior form, after which the bone is more easily replaced.

When the luxation has occurred laterally, the reduction is facilitated by turning the foot away from the dislocated bone, thus opening more widely the cavity for its reception. After reduction, the foot should be kept in strict repose, and signs of inflammation should be met with cold applications or warm fomentations, together with constitutional remedies for controlling the inflammatory tendency.

In case all efforts at reduction fail, amputation or resection may be considered, the choice of operation depending, in some degree, upon the amount of injury to the circulation and innervation of the foot.

Dislocations of the Scaphoid and Os Calcis.—These bones are found displaced separately, or simultaneously. The study of the anatomical landmarks and comparison with the injured foot, show at once the nature of the injury.

*Treatment.*—Reduction is effected as in dislocation of the astragalus, by making extension with the knee flexed to a right angle, and pressing the bones toward their places.

The principles already laid down should govern the surgeon in the management of irreducible or compound dislocations of these bones. Amputation, or by preference exsection, may be resorted to. As to what results would follow conservative treatment, too few cases have been recorded to enable any estimate to be made of its mortality. I incline to the belief that antiseptic surgery may modify many old notions as to the treatment of foot-dislocations, in the direction of conservatism. In the absence of precedent, the surgeon is at liberty to apply general principles, and to follow his own judgment. Three courses therefore are open to choice, in irreducible dislocations of these bones: (1) To make a section of the ligaments with the tenotome, and then

effect reduction; (2) To leave the displaced bones still unreduced, trusting that, as elsewhere, more or less functional activity may be regained; (3) To remove the foot by Syme's or Pirogoff's amputation.

Dislocation of the Scaphoid and Cuboid from the Os Calcis and Astragalus.—This is the *medio-tarsal* dislocation of Malgaigne and of Hamilton. It is a rare accident; but one which undoubtedly occurs in an uncomplicated form. Cooper and Liston have recorded instances. The foot is bent upon itself, as in congenital talipes. Simple extension is all that is required to bring the bones again into position, after which rest should be enjoined for several weeks, to secure union of the ruptured ligaments.

Dislocation of the Cuboid alone.—Some of the older surgeons assert the possibility of this injury, while others deny that any authentic cases are upon record. Extension, counter-extension, and direct pressure upon the bone, are the means which would probably be required to effect reduction.

Dislocation of the Scaphoid alone.—A number of cases are well attested, in which this bone has been displaced, generally in an upward direction. The prominent tumor, formed by the displaced bone, makes the diagnosis easy when fracture is known not to exist. Reduction is of course effected by pressure upon the bone. By turning the foot away from the side to which displacement has occurred, reduction is assisted, as this widens somewhat the gap into which it is designed to thrust the bone in restoring it to its position.

Dislocations of the Cuneiform Bones.—These bones may be luxated either separately or together. The displacement will be recognized by examining the anatomical landmarks of the part carefully, and by studying the bony framework of the sound foot. The *treatment* is essentially the same as in luxations of the scaphoid, excepting as to the direction of the movements.

Dislocations of the Metatarsal Bones.—The whole of the metatarsus may be dislocated either forward or backward, and individual bones of the group are at times seen to be displaced in various directions. The luxations of all the bones constitute injuries which are easily recognized, and in which reduction is readily accomplished.

In these cases the foot is shortened, and either a prominence or a vacuity exists upon its dorsal aspect, according as the heads of the bones have gone forward or backward. Considerable pain and swelling occur in a short time after the injury, and may to some extent obscure the symptoms, and prevent the determination of the existence or non-existence of fracture.

The *treatment* consists in making extension upon the toes and pressing the heads of the metatarsals toward their places. This is not easy in cases where only one of the bones has been displaced. Where any difficulty occurs, an anæsthetic is needed—in many cases as much to help in diagnosis as in treatment, since it is all-important not to overlook the presence of a fracture, should any exist.

Dislocations of the Phalanges.—These displacements are rare. Blows received upon the ends or sides of the toes, or violent wrenchings of the toes, however produced, are the general *causes*. The direction of displacement may be forward or backward, usually the latter.

The *diagnosis* cannot be difficult, except in cases of fracture, or where the swelling is great. The *symptoms* are too obvious to need description. The

*treatment* is similar to that practised in dislocations of the fingers. Luxations of the small toes are readily reduced by extension and pressure on the heads of the bones. In the case of the great toe, there may arise difficulty similar to that seen in dislocations of the thumb, and reduction may be found wholly impossible, save by division of the lateral ligaments with the tenotome. Excision or amputation may be considered, if this is not thought advisable, and more particularly in cases of compound luxation, in which the ordinary principles governing joint injuries are applicable, as laid down in another section.

## "Bone-Setting" and "Natural Bone-Setters."

The title of *natural bone-setters* is claimed by a peculiar class of empirics, found both in America and abroad. In Spain they are termed *Algebristas*. In the United States, those who have claimed this power have been mostly members of one family, or have claimed to be such. They have mainly practised in the New-England States and in New York. Among the ignorant classes, a belief prevails that certain persons are born with a natural instinct, or knack, which enables them to diagnose and "set" obscure or difficult cases of dislocation which have proved too much for the skill of educated surgeons. Sir James Paget, in an address to his class, thus refers to the "bone-setters" met with in England:—

> "Few of you are likely to practise without having a bone-setter for your enemy; and if he can cure a case which you have failed to cure, his fortune may be made and yours marred."[1]

It would be unnecessary to spend time in describing the performances of these itinerants, were it not for the grain of scientific truth that, only half understood by themselves, and often wholly ignored by the profession, lies concealed under the curious mixture of ignorance and wilful misrepresentation in which their practice largely consists.

The cases in which these persons succeed in making cures, are certain chronic forms of lameness, or other disability, following various acute diseases, or dislocations and sprains.

These are the cases in which they confidently pronounce the limb "out," or "out of joint," though every man who understands anatomy can see at a glance that the bones are perfectly in place. In many cases, they actually wrench loose certain ligamentous adhesions presently to be mentioned, and in others they gradually loosen up, by exercise, parts stiffened by disuse, and thus set patients on the road to recovery, who had in vain followed the cautious advice of educated surgeons. Those bone-setters who lack tact and judgment, not unfrequently do serious and dangerous mischief by their manipulations, in cases of traumatic synovitis, but others are cautious, and reject cases in which inflammation is present, as unsuited to their art. Only a small part of their business consists in setting real dislocations; but their "natural gift" consists largely in declaring every injured limb to be "out of joint," no matter what the lesion really is, and in proceeding to what they pretend, or perhaps believe, to be a "setting."

Dr. Wharton P. Hood, who personally took a course of instruction under one of these bone-setters, gives a typical description to illustrate the cases benefited by his bone-setting preceptor, as follows:—

[1] Wharton P. Hood, On Bone-Setting, etc., p. 3. London, 1871.

A healthy man sustains a fracture of the forearm. Splints are applied in the usual way, and occasionally re-applied. After a number of weeks the bones are united, and the man is discharged, cured. He is still unable to use either his hand or his forearm, but is assured that his difficulty arises only from the stiffness incidental to their long rest, and that it will soon disappear. Instead of disappearing, it rather increases, and in due time he seeks the aid of a bone-setter. The arm and forearm are then bent nearly at right angles to each other; the forearm is intermediate between pronation and supination; the hand in a line with it; and the fingers are straight and rigid. Passive motion can be accomplished within narrow limits, but produces sharp pain, localized in some single spot about each joint, in which spot there will be tenderness on pressure. The bone-setter will tell the man that his wrist and his elbow are "out." The man may object that the injury had been in the middle of the forearm. The reply is that perhaps the forearm had indeed been broken as alleged, but that the wrist and the elbow had been "put out" at the same time, and that these injuries had been overlooked by the doctors. The bone-setter would then, by a rapid manipulation hereafter to be described, at once overcome the stiffness of the fingers, and enable the patient to move them to and fro. The instant benefit would dispel all scruples about submitting the wrist and the elbow to manipulation, and these also would be set free in their turn. The man would go away, easily flexing and extending his lately rigid joints, and fully convinced that he had sustained grievous harm at the hands of his legitimate doctors.

The traditional pathology of the natural bone-setters is that everything is "out"—that is, dislocated—and that their manipulations "set it." Sometimes a trick is resorted to, to give the patient the sensation of something "slipping into joint." For instance, the following case fell under my own notice:—

A patient sprained the articulations of the centre of his tarsus, but, after careful examination by a thoroughly trained surgeon, no displacement of the parts was found. The inflammation and swelling were slowly subsiding, when the foot was submitted to a "natural bone-setter." He at once found a bone "out," as usual; and placing a thumb with firm pressure on the extensor longus pollicis tendon, on the dorsum of the foot, he dexterously manipulated, so that the tendon slipped suddenly sideways from under the end of his thumb, with a sharp, painful sensation. The patient probably believes to this day that he felt the bone "slip into place," and attributes his continued recovery to the "setting."

As far as "natural bone-setting" consists of mere tricks and lies, we may dismiss it with other forms of quackery, but that part of the business which consists in restoring joints to usefulness, which educated physicians have been unable to cure, is well worth the attention of scientific men.

The art and science of "natural bone-setting," as practised by the best specimens of the craft, may be summed up in about four propositions:—

(1) All troublesome joints are "out."

(2) If there is no active inflammation, they are to be "set" by the manipulations presently to be described.

(3) Inflammatory cases are to be rejected, or else treated until soothing measures have subdued the inflammation, and then "set."

(4) All subsequent improvement is to be ascribed to the "setting."

The real state of facts is as follows:—

(1) Joints which for various reasons have been kept immovable for several weeks or months, become more or less fixed in position from the contraction of muscles and ligaments, which, having never for a long time been put on the stretch, adjust their nutrition to their shortened form.

(2) When injuries have occurred in the vicinity, certain parts may become adherent, such as tendons to their sheaths, or planes of ligamentous fibres to other planes, above or beneath them, on which they ought to slide freely.

(3) Nerve twigs running between movable parts may become adherent from plastic effusion, so as to be dragged upon every time movements take place.

(4) In a few cases, slight partial adhesions of synovial surfaces occur, which, being ruptured, liberate the joint from its bonds.

A vigorous twist, with full flexion and extension, stretches contracting parts, and often ruptures abnormal adhesions, thus curing the patient; and it makes no difference whether this is done by the manipulations of a bone-setter, or by an accidental fall or wrench.

For instance, a gentleman in Chicago, who had his knee badly stiffened, as the sequel of an accident, was limping along in unusual haste one day, when he fell and doubled his knee forcibly under him. The result was an immediate and complete cure of his lameness.

In case of mere contraction of muscles and ligaments, the cure can usually be obtained by gradual increase of movement; but if nerve-twigs are adherent, or if the patient is hysterical or very nervous, the pain attending each effort frightens the sufferer, and the plan of gradual extension cannot be carried out. These are cases for the bright triumphs of the bone-setter, who gets hold simultaneously of the imagination and of the limb, and heroically ruptures the adhesions.

Cases of synovitis are injured by such treatment, and the more ignorant of the bone-setters often do irreparable mischief by wrenching joints which are thus affected, but those who have more tact learn from experience, or from the traditions of their elders, to recognize and avoid cases attended by inflammation. Some, however, use poultices, etc., and, after the inflammation has subsided, proceed to their manipulations.

The bone-setter seeks, or pretends to seek, for some spot about each stiffened joint, which is painful when motion is attempted, and which is also tender upon pressure. This is the point of adhesion to be ruptured. Dr. Hood lays much stress upon the importance of pressing the thumb firmly upon such spots while making the motions necessary to rupture the adhesions, but as far as I can judge of his reasons, the thumb-pressure seems to me unnecessary. However this may be, these points are the points of pain and of resistance on attempting motion, and consequently the points where rupture or stretching must be effected. Their position will assist the operator in deciding what direction to give to his forced movements. In general terms, therefore, the forced motions are to be those which are most painful, and which are opposed by the greatest resistance. The points of thumb-pressure are said to be, in the majority of cases, on the back or front of the carpus, if the wrist is affected; on the tendon of the biceps, at the bend of the elbow, if that joint is stiffened; on or near the point of the coracoid process, in the case of the shoulder; near the ligamentum patellæ, in that of the knee; and about the malleoli, in that of the ankle.

The manipulations of Hutton, an English bone-setter, were, according to his pupil Dr. Hood, as follows: If an interphalangeal articulation were stiffened, the bone-setter first got a firm grip upon the patient's proximal phalanx by passing the left index-finger transversely around or across its palmar surface, and pressing the thumb firmly on the dorsal aspect. He then seized the distal phalanx in the same way, with the right-hand, and forcibly flexed the joint as far as possible. Next he brought the distal phalanx to a semi-flexed position, and then by lateral rocking, that is, by abduction and adduction, he endeavored to stretch the lateral ligaments. The operation was finished by making complete extension. Motion was then found to be

much more free than before, and the patient was directed to keep up moderate, voluntary movements.

The management of the metacarpo-phalangeal articulations was precisely similar, except that, the parts being larger, more of the hands of the operator could be applied in the grasp. In these small joints no attention was paid to thumb-pressure.

At the wrist, the bone-setter took the lower end of the forearm transversely in front of him. Seizing the part above the wrist in such a way that his own thumb would be on the carpus of the patient, he sought the tender, resisting point, and pressed his thumb upon it, grasping the limb at the same time with the whole hand; with the other hand he seized the hand of the patient firmly, and then, after twisting the wrist-joint, suddenly brought it to a position of extreme flexion, and as suddenly straightened it again.

In the elbow, the operator, by various flexions, compressions, and rotations, ascertained the motion which was the most painful, and also the position of the tender spot. Then laying the back of his hand on the corner of a table, he received the patient's elbow in his upturned palm, and placed his thumb on the tender spot, which is generally near the insertion of the biceps muscle, and seized the patient's wrist in his right hand. If the previous examination had shown flexion and adduction to be most painful, the operator flexed the elbow, and at the same time pronated it and rotated the arm inward, so as to bring the forearm across the chest; but if flexion and abduction had been found the most painful, he supinated the hand, and rotated the arm outward while flexing. The motions were made suddenly.

There is an obscurity about these terms "adduction" and "abduction." One who attempts to adduct or abduct a flexed elbow, will accomplish nothing but a rotation of the humerus inward or outward, a movement which could have very little influence on adhesions and contractions about the elbow. Probably the whole efficacy of the manipulation lay in the flexion and extension, and in the rotation of the radius.

The shoulder was treated in the same way, first finding the tender spot for thumb-pressure, and the direction of painful motion. The operator then pressed the thumb to its place, generally over the coracoid process, and made a series of strong, rapid motions in such a direction as to rupture the limiting bands.

Hutton used to seek a motion strong enough to communicate a tearing sensation to his hand. I once tried this plan on a case which was precisely like those described by Hood. The tearing sensation occurred as described, but the real benefit of the operation was not superior, if equal, to that obtained by vigorous and well-directed, daily, passive exercises. It might be possible to rupture the axillary artery if there were old adhesions, by making the upward sweep.

In the ankle, the bone-setter took the heel in the palm of one hand, seized the anterior part of the foot in the other, and made two strong, sudden flexions of the ankle, one with an inward and the other with an outward twist. Of course, the magical but useless thumb-pressure was always put on.

In the knee, the plan was, according to the description, uselessly complicated. The patient was seated in a chair, and the operator stood in front of him, with the patient's foot between his knees and thighs. Then clasping the fingers behind the upper part of the calf, and putting on the thumb-pressure, he jerked the knee somewhat upward. Having thus started it, he next hooked an elbow under the knee, and, seizing the ankle, forcibly flexed the limb. If the knee was found bent, the opposite motion was performed. The educated surgeon will see at a glance that these movements, if forcibly made in an old case of fibrous anchylosis, might readily fracture the tibia, an acci-

dent, indeed, which has not unfrequently occurred in the hands of good surgeons.

The hip-joint was treated on similar principles, the flexion force being obtained by placing the patient's leg on the operator's shoulder, while the latter's hands grasped the thigh to rotate it, or steadied the pelvis by pressing down upon the groin. Dr. Hood says that if the limb be "elongated," the flexion should be made in an "abducted" direction. As the limb seldom or never is actually elongated in such cases, I presume that he means the apparent elongation produced by stiffening in a position of abduction.

The whole theory, as far as it contains valuable elements, may be summed up in the following principles:—

1. The points of adhesion in painful cases will be found at the spots which are tender when pressed upon, and when the part is put on the stretch.
2. The points of resistance in cases of painless stiffness are found by moving the part in different directions.
3. These points are to be ruptured by quick, strong motions, and the freedom thus gained must be preserved by daily exercise.

If any one will master these three propositions, and superadd a lying habit of declaring every stiff or painful limb to be "out of joint," he will then become a "*natural bone-setter.*"

It is evident that many cases of lameness may be properly treated by this method, but it is also true that most of them can be better but more slowly cured by systematic exercise. The two classes of cases which require the rupturing plan are:—

1. Those in which there are adhesions so firm that nothing else will liberate them.
2. Those in which the patient cannot remain under the surgeon's care long enough for the employment of the gentler, gradual plan.

## Sprains.

A sprain is a wrench of a joint, of such force as to overstrain and often slightly tear the fibres of the capsular ligament, without dislocating the bones. The ankle and the wrist are the most frequent seats of this injury, but the elbow and the knee are not uncommonly affected, while the shoulder and the hip, owing to the wide freedom of their motions, are seldom the subjects of sprains. In the ankle, sprains are almost invariably caused by an inadvertent step, in such a direction as to turn the sole of the foot inward, and lacerate the outer lateral ligament. In the wrist, sprains result from falls upon the hand. All the articulations of the hand or of the foot are occasionally sprained.

Complications of Sprains.—Although the laceration or overstretching of the capsular ligament constitutes the essential element of a sprain, yet other tissues are often injured. Thus tendons may be ruptured and muscles torn. Still more frequently, the synovial membrane is contused or lacerated, giving rise to a severe synovitis, and small vessels are generally torn, causing extravasation of blood, either within or without the joint, or both. At the wrist, the ligaments are very powerful, and when sprained they often drag with them the articular extremity of the radius, causing a fracture of the lower end of that bone.

Diagnosis.—In joints swollen from the effects of sprains, care is necessary to avoid errors of diagnosis. In an uncomplicated, recent sprain, however

great the swelling, all the bony landmarks will be found in correct, relative position, which fact will exclude the suspicion both of dislocation and of impacted fracture, while the distinction from non-impacted fracture rests upon the absence of crepitus and of abnormal bony mobility. Incomplete fractures may exist without detection, until revealed by the formation of provisional callus.

Symptoms and History.—Immediately after the occurrence of a sprain, there is severe pain, often accompanied with something like faintness and nausea. The swelling generally commences almost instantly, from the effusion of blood into the tissues, and continues afterwards from the advent of inflammation of the parts affected. If the synovial membrane has suffered, there is synovitis, and a consequent rapid filling up of the sac of the articulation with synovial fluid, often mixed with blood. In severe cases the patient is totally disabled, but in mild cases he often continues to use the joint moderately during convalescence. Acute suppuration rarely follows, unless the patient is of a very aplastic or suppurative diathesis; but the chronic synovitis which follows in some of the cases, frequently lays the foundation of caries and suppuration at a later period, if the synovitis be not properly treated. Where synovitis does not supervene, caries and suppuration cannot easily occur. If the patient be of a strongly rheumatic constitution, the local irritation often seems to derive a special obstinacy and persistence from the presence of the rheumatic diathesis.

The inflammatory symptoms in persons of healthy constitution, usually abate in a few days, and in a few weeks disappear; but there is a mechanical trouble which often remains longer, and is even aggravated by the very immobility enforced as a curative measure. The various bands and layers of ligament around a joint, have, normally, certain free, sliding movements upon each other, and transmit small nerves and vessels along their interspaces. When the ligamentous tissue is torn by the sprain, the same force rends the nerve-twigs, and the sensitive fibres thus injured are liable to become entangled in the cicatricial tissue formed during the healing, so that movements of the part are hampered and painful. These are the cases which, as already mentioned, furnish triumphant successes to the "natural bone-setters;" and it is easy to see that the longer the surgeon enforces stillness under these circumstances, the worse his patient's condition may become.

Treatment of Sprains.—The most contradictory precepts have been given respecting the management of sprains, but the following plan accords with the general sense of the profession:—

(1) A severe sprain demands rest in the horizontal position for a few days.

(2) A steady and judicious use of cold will prevent the supervention of severe inflammation, and in a few days all tendency to its occurrence will have passed away, when the cold can be slowly withdrawn. Many favor hot instead of cold applications, and others decide between them according to the sense of comfort or discomfort felt by the patient. Warm-water applications, indeed, do well for some patients; but cold, properly regulated, will irresistibly quench the inflammation in all ordinary cases; and there are few or no patients who will long find it disagreeable, if it be regulated with proper tact and care. Whichever plan of treatment is adopted, should be steadily maintained.

(3) The liquid effusions poured out from the torn fibres into the tissues, during the first forty-eight hours, are irritating, like similar effusions after other mechanical injuries, and there is great advantage in getting rid of them. Unfortunately, the drainage tube cannot be employed here, but by gentle

kneading (*massage*), followed by the application of a bandage, the fluid can be pressed away to less irritated regions, whence it may be absorbed. This effect is rendered possible by the fact, that all the cavities of the connective tissue communicate with each other freely, like the meshes of a sponge. Professor Agnew would postpone massage longer, but experience proves that gentle stroking, with deft and equable hand-pressure, from below upwards, soothes the pain, diminishes the tenderness, and presses away the irritating secretions into other non-inflamed portions of the connective tissue. There is no harm but much benefit to be gained by this measure, if employed with skill and care once or twice a day.

(4) As soon as the acute inflammation, or the tendency to it, is somewhat abated, we must bear in mind the liability of the lacerated layers of ligamentous fibres to form abnormal adhesions among themselves, and to adjacent nerve fibres; hence we must, after a few days, follow the stroking massage, first with passive, and then with active movements of the joint, in all the directions of its normal motion.

In case the synovial membrane participates in the inflammation, the active and passive exercise must be greatly limited. The diagnosis can generally be assisted by pressing the joint surfaces firmly together, in such a way as not to strain any of the tender ligaments. If acute synovitis exists, this pressure will elicit pain, and, as all friction and pressure of inflamed synovial surfaces upon each other is injurious, the surgeon will then be compelled to modify his desire to move the hampered ligaments, and must comply measurably with the demands of the synovial membranes for rest. Fortunately, a very free movement, made once a day, will often suffice to free the ligaments from their adhesions, without seriously retarding the recovery from synovitis.

As time passes on, and it becomes clear that there is no synovial inflammation present, the surgeon should become bolder in his manipulations, and in chronic cases should persist in them, even though some ligamentous irritation should follow each effort. In cases which have become decidedly chronic in spite of gentle exercise, and in which there is neither a rheumatic diathesis nor synovitis present, it will be justifiable to resort to the wrenching plan of the "natural bone-setters," already described, and by strong, forced movements, to rupture the adherent fibres. For detailed instructions as to the methods of these manipulations, the reader is referred to what has been already said on the subject in a preceding part of this article. Finally, if all other measures fail, it may be best in some cases to practise neurotomy on certain nerve-twigs, so as to paralyze the sensation of the adherent spots, and thus rid the patient of his pain.

## Contusions of Joints.

These injuries differ from sprains more in their causes than in their effects. The nature of the lesions, and their subsequent course and treatment, are so closely allied, that what has been said of one class will apply to the other.

## Irritable Joints.

This is the term employed by Prof. Agnew[1] to denote certain cases of sudden inflammation of a joint, occurring weeks or months after the sprain or injury.

[1] Principles and Practice of Surgery, vol. ii. p. 133.

The term irritable joint seems to me not well chosen, because the symptoms described are those of inflammation. Prof. Agnew advises immobility and counter-irritation. If synovitis is present, extension as well as immobility is desirable; in short, the treatment is the same as in other joint inflammations.

## Wounds of Joints.

This very important class of injuries comprises several varieties, viz., incised wounds, punctured wounds, lacerated wounds, compound dislocations, and compound fractures including gunshot wounds. Strictly speaking, these varieties are not always distinct, for a gunshot wound of an articulation is always lacerated, and is generally also a compound fracture; nevertheless this division of the subject facilitates its discussion.

### I. Incised Wounds of Joints.

These are the simplest of the penetrating traumatisms of joints. The *causes*, of course, are the entrance of any sharp instrument into the capsule of the articulation. The primary *symptoms* are not necessarily conspicuous. Generally there is a perceptible effusion of synovia, which, in doubtful cases, serves to establish the diagnosis, and, in some instances, by keeping up a slight outward flow, prevents for several days the entrance of septic bacteria into the cavity, and prolongs the time in which the surgeon has an opportunity to close or guard the orifice, and to prevent the occurrence of purulent synovitis.

The synovial secretion is recognizable by its transparency and viscidity, but the wound of a bursa near the joint may sometimes yield a similar fluid, and thus throw doubt on the diagnosis. In such a case, cautious probing is justifiable, if the probe be dipped in an antiseptic solution, and if the orifice of the wound be kept guarded by irrigation with the same. The intimation of some authors, however, that the surgeon may dismiss his anxiety and his precautions, in case he find only a bursa wounded, is absurd; for many of the bursæ around articulations have open communications with the synovial sacs of the joints, and may propagate through these orifices the most deadly suppurative inflammation.

Treatment.—Incised wounds of joints should be treated throughout with antiseptic precautions of the most thorough character. If carbolic acid is the article selected for the wash or spray, one part to forty is a good proportion. Carbolized oil, for use on lint, should be stronger, say one part to twelve. The examination, the cleansing from foreign substances, the suppression of hemorrhage, and the closure of the wound, should all be effected under antiseptic protection. I am no advocate for all the details of Listerism, and hold the spray especially to be often a very undesirable, as well as an inefficient, antiseptic guard; but in dressing wounded joints it is frequently very useful, though never indispensable. The principle to be acted upon is simply this: that there must be allowed no opportunity for septic particles, floating in the atmosphere, to remain in a living state, either on or in the wound. This is the end to be aimed at, and every well-educated surgeon must select his own means of attaining it.

If the joint have been widely opened, or contaminated by the admission of foreign substances into the sac, the interior must be antiseptically washed out. If the wound be small and recent, and no special reason exist for believ-

ing that the capsule has foreign substances within its cavity, it is best to assume that the blade which wounded it was wiped clean by the outer tissues as it entered, and that the outflow of blood and synovia has prevented septic particles from entering. As a matter of fact, in narrow wounds, the steady outflow of viscid synovia often protects the interior for several days from the entrance of septic influences. The wound, being promptly closed by ordinary methods, should have a thorough antiseptic covering, and should be maintained in a state of perfect immobility. If inflammation occur, cold applications should be vigorously employed, without in the least relaxing the antiseptic precautions. I advocate no servile adherence to the peculiar methods of Lister, or of any one man; nevertheless, in wounds of joints, a skilful use of antiseptic principles is of extreme importance. If the principles are well comprehended, every surgeon can devise his own methods of applying them.

In many cases, the synovial fluid will increase rapidly after the closure of the joint, causing considerable distension of the sac, and this fluid, produced under the inflammatory influence, seems to be of an irritating character. It should be promptly withdrawn, either by repeated aspiration, or by opening a corner of the original wound under antiseptic precautions; and in some cases it is best to insert temporarily a small drainage-tube, keeping it always under strict antiseptic guards.

If suppuration ensue despite all care, or if it have already occurred before the surgeon sees the case, the wound must be boldly laid open in such a way as to admit of perfect drainage, and of regular daily washing out of the interior with antiseptic fluids, of which carbolized water, of the strength of one part to forty, is one of the best.

Incised Wounds of the Knee-joint.—The knee-joint, owing to its size and complexity, has an enormous surface of synovial membrane, amounting to about one hundred square inches, and if we include the bursa under the quadriceps femoris, which very often either communicates with the synovial sac by a free opening, or else constitutes a wide, upward extension of the sac itself, the area will be little short of two hundred square inches.

The synovial membrane of the knee always forms two, and sometimes three cavities, sufficiently separated from each other to prevent one part from being washed out through another, and yet connected enough to allow septic infection to contaminate every corner of the whole.

The lower cavity is formed by that part of the synovial membrane which is below and behind the patella. This membrane covers the top of the tibia, lapping down about half an inch over its edges, and then, turning upward, covers both surfaces of the semilunar cartilages, and extends upward, about an inch, on each side of the condyles of the femur. From the condyles it is reflected downward and forward, covering the whole end of the bone. At the level of the patella, the synovial sac is constricted considerably, and partly shut off from the cavity above by the pressure of the patella and of certain ligamentous folds against the front of the femur. Above the patella the sac expands again into a large cavity, which often extends pretty high behind the quadriceps muscle. Above the synovial sac proper, is the great sub-muscular bursa which separates the quadriceps from the front of the femur, and which is often connected by a large opening with the sac of the joint itself.

The anatomical text-books give a partly erroneous impression, in saying that this bursa does not always exist. For surgical purposes, it is always present; if not as a perfect sac, yet as a very loose connective tissue, which offers no resistance to the diffusion of putrid pus. Even when well developed, the bursa is traversed by a mesh-work of fibrous bands, which grow more

numerous in the upper portion, until they merge into the loose, intermuscular, connective tissue of the thigh. There is usually no definite, upper boundary to the bursa, and an injection thrown into the knee-joint of a cadaver may often be made to run up through this loose tissue to Poupart's ligament. Hence the facility with which pus in the knee-joint will burrow its way upward, and cause vast abscesses in the thigh.

We have, therefore, in point of fact, three large cavities to consider:—

(1) The sub-muscular bursa.

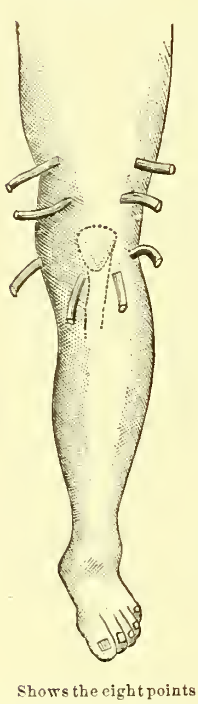
(2) The supra-patellar cavity.

(3) The infra-patellar cavity.

The bursa is sometimes separated completely from the joint, but it is not correct to say that it is ever totally absent from the limb, in such a sense as to exclude the risk of extensive purulent infiltration. When the knee is bent, the patella, with the ligaments on either side, is pressed with great firmness against the front of the femur, closing the narrow isthmus of the sac pretty completely, and effectually preventing the washing and draining of one segment of the synovial sac through the other, or of the bursa through either, while the septum between the joint and the bursa, though often incomplete, prohibits free cleansing of the synovial sac through incisions in the bursa, or of the bursa through the sac. When general suppuration of all the cavities exists, each one must have its own means of drainage. It is for want of appreciating these mechanical facts that surgeons have been so often baffled in attempting to disinfect suppurating knee-joints.

As the nervousness of many patients prevents the daily insertion of a syringe-pipe into openings with raw edges, the washing of the cavities in that way is often difficult. It is, therefore, better to anæsthetize the patient, make all the openings at once, and place drainage-tubes in them, which, once in position, receive injections without pain. Each of the three cavities should have at least two openings, so placed that the purifying injection will enter at one side, and, sweeping across the cavity, pass out on the other, thus completely washing away all putrid pus. Dr. Markoe has shown the value of this principle of "through drainage" in various injuries and diseases, and it is unnecessary to discuss it here.[1]

Fig. 580.



Shows the eight points available for drainage of a suppurating knee-joint.

The best locations for the introduction of drainage-tubes are eight in number, but it is not generally necessary to use more than six on one patient, that is to say, two tubes for each cavity.

The eight points of incision are as follows:—

*a.* One on either side of the bursa;

*b.* One on either side of the supra-patellar, synovial expansion;

*c.* One on either side of the condyles, where the synovial sac is reflected, about an inch above the semilunar cartilages, and near the posterior part of the joint;

*d.* One on either side of the ligamentum patellæ.

These positions are shown in the annexed illustration.

In making use of these points, the following principles will guide us:—

1. If the bursa be not affected, the incisions and tubes for its cavity may be omitted.

[1] American Journal of the Medical Sciences, April, 1878.

2. In the early stages of a wounded knee-joint, the flexing of the knee and consequent closing of the patellar isthmus by the pressure there, sometimes prevents for a time the spread of the pus and of the inflammation from one cavity to the other. In such cases, by keeping the knee bent, and by thorough antiseptic drainage and injection of the single cavity which is found suppurating, I have been able to prevent the inflammation from spreading to the other cavities, and to obtain a cure with but little trouble.

3. Whatever cavities are affected, they should generally, as before said, be drained, each from two points, and sometimes from more. In the cavity below the patella, sufficient drainage can generally be procured by placing one tube in front, by the side of the ligamentum patellæ, and another on the opposite side of the joint, in front of the hamstring tendons, and just above the junction of the femur with the tibia. If the capsular ligament should prove so tense here as to render difficult the insinuation of a tube, the surgeon may facilitate the procedure by extending the incision backward, close under the hamstring tendon, where the capsule is voluminous and loose. By this plan the lower cavity can generally be well washed out, since the fluid passes diagonally through the joint. It should be borne in mind, however, that the back part of the cavity is divided into two lateral pouches by a synovial fold, which is reflected from the back of the joint, forward, to cover the crucial ligaments. Where this causes any difficulty in complete cleansing, it may be necessary to put a tube into each pouch, near the hamstrings, so that a stream thrown into the front opening may divide, and irrigate each pouch.

By effecting the cleansing of all three cavities in this thorough and systematic manner, the practical surgeon will find that suppurating knee-joints are freed from most of their dangers. As this is rarely done, a large portion of the patients thus affected die, not at all from the necessities of the case, but from blood-poisoning, due to the wretched insufficiency of the measures employed to free this complex cavity from its mass of putrefying pus.

Knowing how dangerous it is to open a healthy knee-joint, the practitioner often has a vague idea that there is equal or greater danger in freely opening one which is suppurating, not considering that he has for practical purposes no longer a synovial sac, but only an abscess, to deal with, and that the more widely it is opened, the less dangerous it is. Not comprehending this truth, he proceeds timidly, and with fear and trembling, to inject a little purifying fluid through a single opening into one of the cavities, but fails utterly to disinfect even that one, to say nothing of the other two. Of course he gains nothing, and the patient grows rapidly worse. Thus baffled, the average practitioner has not the courage to make additional openings, or, if he has, he knows not how many of them he should make, nor where he should locate them, and to the shame of surgical literature it must be added that he will find in his text-books no adequate instructions on these vital points.

The systematic treatment of incised wounds of the knee-joint should conform to the above principles, and may be briefly stated as follows:—

If seen in its recent condition, before suppuration has been set up, the wound should be opened and disturbed only as much as is strictly necessary for examination and cleansing from foreign bodies, and this preparatory exploration should be done with careful antiseptic precautions. The cleansing being completed, the wound should be closed and dressed antiseptically, and all subsequent dressings should be conducted with similar care. If the joint have been exposed to the air widely enough to become contaminated with dirt and foreign bodies, it must be not only freed from such objects, but washed out with some suitable antiseptic fluid, carbolized water of the

strength of two and a half parts to the hundred being as safe an article as can be found. If there be no proof that any foreign substances are in the joint, and if there have been no long exposure to the air, the wound may be closed at once without any injection, but should be dressed antiseptically, as before.

As the physician in private practice will not find at his patient's bedside a pair of steam-spray machines, with all the other complex appliances of "Listerism," it will be well to describe here an extemporaneous antiseptic plan, which can be carried out in any place where carbolic acid, or any other good antiseptic, can be obtained.

First let the surgeon prepare a quantity of carbolized water of the strength of about two and a half per cent., or one part of crystals, or of 95 per-cent. acid, to forty of water. This can be used to wash the wound, to syringe the joint,[1] and to apply as a wet dressing. As a substitute for the carbolic spray, let an assistant, during the dressing, keep a little of the two-and-a-half per cent. solution dripping constantly across the wounded surface, which will effectually prevent all septic infection from without. Sutures and adhesive plasters may be used if needed. A thick compress of cotton batting, lint, or soft towelling, soaked in the carbolized water, may now be laid on the closed wound, and the whole covered with strong paper dipped in melted lard, tallow, cerate, or wax. A wrap or bandage retains the whole in position. Such a dressing will remain perfectly aseptic for twenty-four hours. If longer intervals between the dressings are required, it is better to soak the cotton or lint compress in a mixture of one part of crystals of carbolic acid, in twelve parts of any bland oil, or of glycerine. Such a compress, covered with oiled paper, will retain its antiseptic powers perfectly for several days.

With materials thus extemporized, a practitioner who comprehends the principles of the art can make absolutely antiseptic dressings.

If inflammation has ensued in the synovial sac, and has as yet only invaded one segment of it, then a small opening should be maintained in one angle of the wound, under antiseptic guards, in order that the irritating fluids may escape freely, and not accumulate under a pressure which would lift the patella, and allow them to enter the other segment of the sac. To prevent this, it is well to temporarily flex the knee somewhat, and thus constrict the isthmus of the synovial cavity in the manner already explained. If, however, the disease has spread to the whole cavity, the flexed position should not be long maintained, lest it become permanent.

If suppuration invades the entire joint, it puts the patient in serious peril of his life, unless resolutely treated. The pus undergoes decomposition, and rapidly poisons the blood by absorption. It fills not only all the deep, complex pockets below the patella, but the wide sac above it, and often penetrates along the meshes of the great bursa above, and converts the whole front of the thigh into a long, diffused abscess, whose vascular walls absorb the putrefying fluids with deadly rapidity. In addition, caries is often induced in the articular surfaces, forming a very grave addition to the previous troubles.

I have been thus particular in describing the management of incised wounds of the knee, because of their great danger, and of the wretched inefficiency of the treatment ordinarily adopted. The limits of this article do not admit of equal details regarding all the other articulations, but the principles are the same, and with these, guided by his anatomical knowledge, the surgeon

[1] Two and a half per cent. is the proper strength for syringing out a suppurating joint cavity. To wash out a healthy, freshly exposed, synovial sac, not yet suppurating, one half this strength will be better.

need not hesitate about his duty. Macnamara[1] advises to drill through the bones into suppurating joint cavities, for the purpose of drainage, but his suggestion has not proved acceptable to other surgeons, since it is easier and simpler to make openings, wherever needed, in the capsule.

The drainage-openings of the hip may be made behind or in front of the trochanter, and those of the ankle on either side, below or in front of the malleoli. The tarsal articulations may be opened wherever they are most accessible. The joints of the phalanges should be drained from the dorsal aspect. The wrist-joint is to be reached on either border, a little towards the dorsal side. The elbow can be opened around the border of the olecranon, and at the junction of the head of the radius with the humerus. The shoulder can be drained in almost all directions, but especially anteriorly and externally.[2]

From the earnestness with which I have recommended drainage by incisions and tubes, no one should infer that it is proper to neglect a vigorous use of cold and other antiphlogistic measures in the early stages. Antiseptic drainage should be simply added to and not substituted in the place of, other treatment. All these rules, of course, will be often modified by the location of the original wound.

## II. Punctured Wounds of Joints.

Punctured wounds of joints often recover with surprising ease. If made by a slender weapon, the opening closes instantaneously without admitting any air, and though some acute synovitis may follow, it is in most cases easily managed by cold applications, and not very apt to terminate in suppuration. Should it be otherwise, however, and pus be formed, the principles already inculcated must be applied. As the first step, the cavities of the joint may be emptied once or several times by the aspirator. If the pus grow more watery with each aspiration, and be free from offensive odor, and the inflammation abate, there will be hope of a complete cure by aspiration alone, or by aspiration conjoined with antiseptic washing of the cavities through the aspirator tube; but if the parts do not improve, then free incisions must be made, and antiseptic treatment in full be adopted, as in cases of incised wound.

Punctures of Finger-joints.—One of the most common joint-wounds of the punctured variety is made by biting. Men of the lower class, in fighting, have a strange proclivity to bite each other's fingers. A tooth penetrating a digital articulation sets up suppurative inflammation, and the putrid effusions, finding no ready escape on account of the closure of the puncture, burrow around the phalanges, strip off their periosteum, and lead to necrosis. These wounds should be tested at the outset with a fine probe, to discover any opening into the joint, and if one be found, it should be antiseptically treated at once. If it be seen after inflammation of the articulation is already fully set up, free incisions made immediately, and full antiseptic measures, will prevent very severe mischief.

[1] Diseases of the Bones and Joints, p. 115. London, 1881.

[2] Baden has published a valuable article on incisions for drainage of joints (Berlin klin. Wochensch., Aug. 6, 1877). Packard, in his edition of Holmes's System of Surgery (vol. iii. p. 245), discusses the matter briefly. Articles bearing on the subject may be found in various periodicals, especially Edinburgh Medical Journal, September. 1875; Lancet, 1875; British Medical Journal, September, 1875; Gazette Médicale de Strasbourg, 1 Sept. 1877; Schmidt's Jahrbücher, Band 174, S. 268; Deutsche Zeitschrift für Chirurgie, Band x. S. 296; Deutsche med. Wochenschrift, 24 Nov. 1877; Centralblatt für Chirurgie, Dec. 8, 1877; Ibid. S. 480, 1878.

## III. Lacerated Wounds of Joints.

The principles of treatment in these severe injuries are similar to those already laid down for the management of incised wounds, but the hope of union without pus-formation is very slight, and the surgeon will generally have to combat the suppurative tendency from the outset. As far as these wounds belong to the class of compound dislocations, they have already been considered in a previous portion of this article.

The other causes of lacerated joint wounds are the violence of machinery, falls upon angular objects, and all the various accidents which may wrench the bones far enough from their proper relations to lacerate their surrounding soft parts. The elbow is especially subject to lacerated wounds when bent suddenly backward. Thus a lady was overturned in her carriage while the horses were running away. As the side of the vehicle neared the ground, she put her hand through the open window against the pavement. The carriage, still rushing forward, brought the window frame against the back of the elbow, bending the forearm violently backward. The bones were not fractured, but the anterior ligaments gave way, with most of the soft parts on the anterior aspect of the articulation, laying the joint widely open. Under thorough antiseptic treatment the parts healed with no other disaster than anchylosis.

Lacerated wounds will sometimes unite by first intention; hence in recent lacerations of joint capsules, and of their overlying tissues, the surgeon should consider whether he may not, by prompt antiseptic closure and adoption of the subsequent measures advised in speaking of incised wounds, preserve a useful articulation. If nothing prohibit the attempt it should be undertaken with the same care and minute attention to the perfection of antiseptic precautions, which have already been recommended in cases of incised wound. If the effort fail, and suppuration ensue, or if the purulent stage have already set in when the patient comes under the surgeon's care, then the treatment must be by drainage tubes and injections, or, if caries have set in, amputation or resection may be required.

## IV. Gunshot Wounds of Joints.

These injuries are generally both lacerated wounds and compound comminuted fractures, though in a few cases a bullet, cutting along the side of a joint, merely opens the capsule without shattering the bone. The army rifle-bullet is large, and when it passes directly through an articulation, it generally reduces a large part of the ends of the bones to a fine gravel, consisting of comminuted, osseous and cartilaginous material, besides splintering the remoter portions of the articular, osseous extremities. The large quantity of bony gravel left in the joint places it in a very different situation from that of an ordinary compound fracture, and stamps as idiotic all efforts to treat cases attended with such comminution in a merely conservative manner, whether with or without antiseptics. The first thing, therefore, in a case of penetrating, gunshot fracture of a joint, is to examine carefully, and determine whether the bone be comminuted or not. If the capsule be merely cut open, leaving the bone untouched, the treatment may be as in other cases of lacerated joint-wound. If the bone be broken, but not comminuted, the case may be treated as other compound fractures of joints, but if it be badly comminuted, the surgeon must generally choose between amputation and excision, or the

semi-conservative course of opening the articulation, and clearing out the fragments. If there are any situations in which a more strictly conservative plan would be admissible, they are in the hip-joint and in the spinal articulations, where it is obvious that certain complications may compel surgical inaction as to an injured joint, when otherwise an operation would be imperative. Common sense and not arbitrary rules must guide in such cases.

Gunshot Wounds of Vertebral Articulations.—A long discussion of these injuries would not be appropriate here, because their chief importance consists in the mischief done to the cord, and not to the articulations as such.

The vertebræ, being composed of cancellous tissue, are very liable to absorb, through their opened and non-contracting venous channels, a vast quantity of putrid material; hence septicæmia is very liable to occur, as in the case of the late President Garfield. This disaster can be prevented in a few cases, where the wound happens to be so located as to admit of exploration with some degree of safety. It is therefore a sound doctrine to explore such wounds to the bone, if it can be done without much risk, and to try to establish drainage and an aseptic condition in the bone-wound itself; but if the exploration be likely to evacuate the spinal fluid, or do other fatal mischief, it is idle to pretend, as some have done, that such an examination should be persisted in, even at the risk of hastening death. It is to be remembered that a bullet is itself generally antiseptic, being covered with condensed sulphuric and sulphurous acids from the combustion of the powder in the gun, and that its passage through cancellous bone by no means insures septicæmia. In many cases, an exploration pushed far enough to reach the perforation in the vertebra, would be more dangerous than to trust that part of the wound to nature. There have been as yet no sufficient statistics accumulated as to vertebral wounds, to enable us to lay down precise rules of conduct, and until science does us this service—a very difficult, if not an impossible service in this class of cases—each surgeon must be guided by his best judgment on general principles. Those writers who allege that surgical science has a settled rule for every possible contingency, do not consider, or do not know, the actual state of surgical literature.

Dr. Otis[1] gives a table of 642 cases of wounds of vertebræ, with 55½ per cent. mortality. He gives also a table of sixty cases, in which various operations were performed upon the wounded vertebræ, with 27 deaths, which is a mortality of 45 per cent. The unavoidable, mathematical inference from these figures is, that the cases operated on were ten-and-a-half per cent. more successful than the average of the whole; but there is no practical value in this inference, because it is not known whether those selected for operation were cases of average severity.

The only conclusions, therefore, which are at present admissible, are these: In gunshot fractures of the spine, very careful examination should be the rule, and in many cases incisions should be made with judicious boldness, both to assist the exploration, and to enable the operator to remove fragments of bone, bullets, and pieces of clothing, and last, but not least, to enable him to thoroughly drain the fracture, and to keep it purified with antiseptics. In other respects the patient must be treated according to general principles, guided by the special study of each case.

Gunshot Wounds of the Shoulder-joint.—These vary exceedingly in gravity, as do similar injuries elsewhere. The joint may be torn to frag-

[1] Med. and Surg. Hist. of the War of the Rebellion. Part First, Surgical Volume.

ments, or simply opened, or may suffer any intermediate degree of destructive action. In bullet wounds of the shoulder, the orifice in the thick deltoid muscle is apt to contract and resist the free exit of pus, and lead to a destructive burrowing of septic fluids. If the joint be opened, and the bone merely notched or grooved by the bullet, without being shattered, it will not usually be necessary to amputate or excise, but only to open the parts freely, and treat them antiseptically. If the bone be shattered, we have to consider more energetic measures, or, in other words, we must choose between amputation and resection. For a shoulder-joint badly shattered by a bullet, mere conservative treatment is too dangerous to be considered. The Medical and Surgical History of the War of the Rebellion, it is true, seems to show an advantage of several per cent. in favor of expectant treatment, but if we reflect that the cases selected for this plan were the least severely injured, the apparent statistical advantage is more than accounted for by the mildness of the cases. He would be a rash man who should be so infected with conservatism as to leave to unaided nature a shoulder-joint filled with bony gravel from the comminution of the humerus.

As between amputation and resection, the difference shown by several collections of statistics is only about two per cent. The most valuable tables on this subject are those collected by Dr. Otis, in the Medical and Surgical History of the War of the Rebellion, and by Dr. H. Culbertson, in his prize essay, published by the American Medical Association in 1876. The brevity of this article does not admit of a full statement of all the statistics bearing on this subject, but from a careful search of the literature of both continents, supplemented by the above-named documents, I have been able to condense the following results:—

| Mode of treatment. | Cases. | Deaths. | Mortality per cent. |
|---|---|---|---|
| Expectant treatment . . . . . . . | 577 | 144 | 25 |
| Amputation at shoulder for traumatic causes (nearly all gunshot wounds) . . . . . . . | 1177 | 457 | 39 |
| Resection of shoulder in similar cases . . . | 1408 | 518 | 37 |

It will be seen, therefore, that resection appears to be somewhat safer than amputation, besides preserving a very useful limb. As between primary, intermediary, and secondary operations, the intermediary are considerably the most fatal, but the primary and secondary do not greatly differ. The conclusions are obvious:—

(1) In gunshot wounds of the shoulder, with but slight injury to the bone, we should open the joint widely, and treat it antiseptically.

(2) In comminuted fractures, where the circulation and innervation are tolerably well preserved, we should resect the joint.

(3) Where the innervation and circulation are destroyed, or nearly so, we should amputate.

(4) Primary operations are to be preferred.

Gunshot Wounds of the Elbow-joint.—The degree of comminution of bone in these injuries varies extremely, but even in the most favorable cases, the results of the wound are very serious. The complexity of the joint is such that it is difficult to drain it, or disinfect it, with any completeness; hence purely conservative treatment has not such success as one could desire, even when the bones are but slightly injured. Demme and Salzmann give the mortality of conservative treatment at sixty per cent., yet in General Sherman's campaigns, Drs. Andrews and Woodworth found only twenty-five per cent. of deaths, showing that in well-selected cases expectancy is admis-

sible.[1] Generally, however, the comminution is such that we have no choice except between amputation above the elbow and excision of the joint. In regard to the selection between these two operations, such contradictory opinions have been expressed by eminent authorities, that surgical literature on this point is eminently confusing. This state of affairs can only be accounted for by supposing that many authors of prominence have preferred to form opinions by guesswork, rather than by a laborious sifting of facts. It is necessary, therefore, to discuss the question with some care, in order to reach the solid truth. The following statistics have been gathered with much labor. From the mode of collection adopted by different authors, a part of the cases are undoubtedly included twice, but it is impossible to completely separate them, and as the reduplication includes recoveries and deaths alike, it probably does not materially alter the ratio of mortality:—

### Shot Wounds of the Elbow treated without Operation.

| Authority. | Cases. | Deaths. | Mortality per cent. |
|---|---|---|---|
| Otis, Med. and Surg. Hist. War of the Rebellion . . | 924 | 96 | 10 |

### Shot Wounds of the Elbow treated by Amputation of the Arm.

| Authority. | Cases. | Deaths. | Mortality per cent. |
|---|---|---|---|
| Otis, Med. and Surg. Hist. War of the Rebellion . . | 1119 | 272 | 24 |

### Amputation of Arm for Gunshot Wounds of various Locations.

| Authorities. | | Cases. | Deaths. | Mortality per cent. |
|---|---|---|---|---|
| Med. and Surg. Hist. War of the Rebellion . | Primary | 3259 | 602 | ... |
| " " " " | Intermed. and second. | 1313 | 416 | ... |
| Andrews and Woodworth's Surgery of General Sherman's Campaigns . . . | Primary | 55 | 5 | ... |
| | Secondary | 4 | 1 | ... |
| Chisolm, of Confederate Army . . . . | Primary | 294 | 42 | ... |
| " " " . . . . | Secondary | 140 | 53 | ... |
| Warren, of Confederate Army . . . . | Primary | 92 | 16 | ... |
| " " " . . . . | Secondary | 100 | 38 | ... |
| Various Surgeons, Franco-German War . . | Primary | 22 | 10 | ... |
| " " " " . . | Secondary | 16 | 9 | ... |
| Schmidt's Jahrbüch. Bd. 156. Crimean War | Primary | 849 | 489 | ... |
| " " " " . | Secondary | 146 | 86 | ... |
| " " " Schleswig-Holstein | Primary | 19 | 9 | ... |
| " " " " " . | Secondary | 12 | 8 | ... |
| " " " Siege of Antwerp . | Primary | 9 | 1 | ... |
| " " " " " . | Secondary | 2 | 1 | ... |
| Guthrie's Commentaries. Brit. Army, 1815 . | Primary | 21 | 4 | ... |
| " " " " . | Secondary | 51 | 13 | ... |
| | Totals . . | 6404 | 1803 | 28 |

[1] The report of Surgeon-General Chisolm, of the Confederate Army, gives 55 gunshot wounds of the elbow treated conservatively, with only 22 cases of anchylosis, and 11 deaths. Of 103 gunshot wounds of the knee, only 21 ended in anchylosis. Other statements are equally surprising. As these results seem contrary to all experience elsewhere, I hesitate to accept them, and have omitted them from my tables. The figures were probably obtained from the records of surgeons who made out their returns in haste, and reported all injuries of the part as "wounds of the elbow," though the bullet had not, in all cases, opened the articulation.

EXCISION OF THE ELBOW FOR GUNSHOT WOUNDS.

| AUTHORITIES. | | CASES. | DEATHS. | MORTALITY PER CENT. |
|---|---|---|---|---|
| Med. and Surg. Hist. War of Rebellion. | Primary | 318 | 68 | ... |
| " " " " | Intermediary | 196 | 69 | ... |
| " " " " | Intermed. and second. | 250 | 74 | ... |
| " " " " | Purely secondary | 54 | 5 | ... |
| Andrews and Woodworth, Surg. of Sherman's Campaigns | | 7 | 3 | ... |
| Chisolm, Confederate Army | Primary | 25 | 3 | ... |
| " " " | Secondary | 36 | 6 | ... |
| Warren, " " | Primary | 1 | 1 | ... |
| " " " | Secondary | 3 | 2 | ... |
| Esmarch, quoted in Gant's Surgery, p. 675 | Primary | 11 | 1 | ... |
| " " " " | Secondary | 29 | 5 | ... |
| Deutsche Zeitschrift. f. Chir. Bd. 1 und 2, Franco-German War | Primary | 12 | 3 | ... |
| | Secondary | 64 | 16 | ... |
| Herrgott, Siege of Strasbourg | Primary | 4 | 1 | ... |
| " " " | Secondary | 7 | 5 | ... |
| Culbertson, op. cit., p. 495 | | 592 | 113 | ... |
| | Totals | 1609 | 375 | 23 |

In these tables, excision of the elbow is shown to be safer than amputation of the arm, for gunshot wounds. Conservative treatment shows even better results, on paper; but when we reflect that the slighter wounds (many of them merely buckshot wounds) were selected for conservative treatment, the apparent superiority of conservatism disappears, except for selected cases. Extraction of the loose fragments of bone, without excision, has been practised in a few instances with very favorable results; but there are no copious statistics which can be said to determine the value of the operation. At present, it is a matter for the individual judgment of surgeons.

As the tables establish beyond dispute that resection of the elbow, in proper cases, is as safe or safer than amputation of the arm, for gunshot fractures of the joint, and since by resection we save that most important member, the hand, we cannot doubt a moment about our duty, when the condition of parts admits of choice. The remarkable confusion and contradiction of opinion among surgical writers, on this point, may be seen from the following abstract:—

Chenu's statistics of the French army showed such a terrible mortality from this resection that Sédillot declared that it ought to be rejected from military practice.

On the other hand, the German surgeons in the Schleswig-Holstein war claimed a brilliant success with it. Hugelshofer,[1] after condemning partial resections as dangerous, asserts that complete resection is safer than amputation above the elbow, and remarks, "be the functional results good or bad, as you will, the preservation of a certain number of human lives which would have fallen a sacrifice to amputation of the arm, or to conservative treatment, must give the operation the first place in treatment of wounds of the elbow-joint." Heyfelder says that the results of resection of the elbow are brilliant, and he gives statistics[2] to show that partial resections are rather more dangerous than complete ones. Stromeyer recommends the operation. Demme and Salzmann say that resection of the elbow for gunshot wounds is three times as safe as conservative treatment. They put the mortality without operation at over sixty per cent.

In America, Ashhurst, Hamilton, and both the elder and the younger Gross approve the operation.

Hannover[3] opposes the operation bitterly, declaring that of sixteen army cases, only one terminated in anchylosis, and that when anchylosis fails, the limb is useless, and burdensome to such an extent that the soldier at last desires it amputated.

[1] Deutche Zeitschrift für Chirurgie, Bd. 111, S. 8.
[2] Lehrbuch der Resectionen, S. 246.
[3] Deutsche Zeitschrift, Band 111, S. 7.

On the other hand, Hugelshofer says that a stiffening of the false joint is generally obtained, sufficient to give a useful limb. Lücke, of Berne, admits that absolutely firm anchylosis is not usually obtained; but affirms that a loose arm is better than none. Neudörfer holds the operation in high esteem. Billroth, of Vienna, says that of sixteen excised elbows in his observation, which remained movable, every one was more or less useful. Bickersteth, of Liverpool, says that of forty cases, thirty-eight survived, and all had useful limbs. Gant recommends the operation. Holmes considers resection probably more dangerous than amputation. Erichsen favors resection in proper cases. Max Schmidt[1] says that conservative treatment of gunshot wounds of the elbow is the most dangerous method, amputation the next, and resection the safest of all.

The above are samples of the contradictory precepts taught by the masters in surgery. Fortunately, we have a vast accumulation of tabulated experience to illuminate the question, which might otherwise be darkened by a cloud of wild and hasty conjectures.

The question of whether the resection should be primary, intermediary, or secondary, may be stated as follows: Like many other operations, this resection is safest when done at a very late period, after all inflammation has passed away, and when continued inaction has atrophied the limb. The next safest time is during the primary period, that is, during the first twenty-four hours. The most dangerous period of all is the intermediary one. The superior safety of the late secondary period does not, however, prove that the surgeon should delay the operation to get the benefit of that time. During this time of waiting, the grave dangers of expectancy are incurred, and a large number of lives are lost. The operation should be done, if possible, in the primary period; but if the surgeon see the case for the first time in the height of the acute, inflammatory stage, it may be proper, in some cases, to strive to abate the first fury of the inflammation, by the use of cold and antiseptics, before proceeding to operative measures. This is only an inference of the judgment, however, as there is no tabulated experience on record to show whether more lives would be saved or lost by temporary delay in such cases.

*Conclusions.*—In spite of the former conflict of opinion, the main principles of treatment in gunshot wounds of the elbow may be considered as now settled.

(1) Slight wounds may be treated without operation, by cold, antiseptics, and free drainage.

(2) Wounds which destroy the innervation and circulation of the forearm sufficiently to threaten its mortification, indicate primary amputation.

(3) Almost all other cases demand primary resection.

(4) Complete excisions are better than partial ones.

*Prothetic Apparatus for Cases of Excision of the Elbow.*—Nothing can be more absurd than the opinion of Hannover, that a limb with a resected elbow is worse than useless if it fails of anchylosis. If the false joint be very loose and unmanageable, nothing is easier than to strap upon it an angular concave splint, which any tinman can make in twenty minutes, and the patient will have instantly all the advantages of anchylosis. A trifling additional labor will give the splint an adjustable joint, capable of being locked in any desired position, thus making the limb far superior to one which is rigid; besides, the false joint is, in many cases, capable of voluntary flexion and extension, making it far better than any stiff elbow, so that it is doubtful whether bony anchylosis is ever desirable, while it certainly is not so generally.

The destruction of the bone and of its covering is usually so complete

[1] Schmidt's Jahrbücher, 1872.

that sub-periosteal resection cannot be practised; but in some cases a part, at least, of the periosteum can be preserved.

In cases where the condyles of the humerus are not destroyed, that bone can be cut across in its broad, thin part, and, by forming a false joint where its edge rests on the cut ends of the radius and ulna, it makes a most excellent, hinged articulation, which, as above remarked, is largely under the control of the patient's voluntary muscles, and which requires no splint to give it firmness. Some of these cases rank among the highest triumphs of surgery.

Gunshot Wounds of the Wrist-joint.—These wounds make serious mischief, and, notwithstanding the small size of the part involved, are attended by considerable danger. The pus permeates the complicated cavities of the articulation, becomes putrid, and can with great difficulty be washed or driven away. Increasing in quantity and putrescence, it often burrows among the tendinous sheaths and bursæ of the palm of the hand, and also works its way among the muscles of the forearm, causing both local destruction and general septicæmia.

In slight cases, conservative treatment is justifiable, but, in severer forms, excision of the joint is to be preferred. Amputation is not required unless the hand is actually dead. In cases justifying conservative treatment, the wound must be opened freely and drained with the utmost thoroughness, and antiseptic injections and dressings should be employed. All burrowing cavities should be opened freely and promptly, and should be kept well drained and disinfected.

Surgeons have not yet settled the question as to whether partial are more or less dangerous than complete resections; but the few statistics thus far gathered seem to indicate that partial resection may be safely resorted to whenever the condition of the parts renders it mechanically desirable.

The statistics of gunshot wounds of the wrist are very meagre, and the whole literature of the subject is scanty. The following figures, however, give the results of a considerable number of cases:—

Treatment of Gunshot Wounds of the Wrist-joint.

| Authorities. | Treatment. | Cases. | Deaths. | Mortality per cent. |
|---|---|---|---|---|
| Otis . . . . . . . | Expectant | 707 | 54 | 8 |
| Otis, Culbertson, and S. W. Gross . | Excision | 203 | 28 | 14 |
| Otis . . . . . . . | Amputation at wrist | 18 | 2 | 11 |
| Otis . . . . . . . | Amputation at forearm | 589 | 90 | 15 |

*Conclusions.*—The hand, after excision of the wrist, is of considerable value, though very far from equal to a sound member. The surgeon should therefore try his best to avoid an operation. If the injury is slight, conservative treatment is the best. If severe, excision is to be preferred, and amputation is to be reserved for such destructive wounds as leave no rational hope of saving the hand, or any part of it.

Gunshot Wounds of the Hip-joint.—These are most desperate injuries. Owing to the fact that they occur almost solely in adults (being rarely met with except in military practice), they are affected by the general law, that after that development of the hips which occurs at puberty, all injuries of the pelvic and adjacent organs involve a great increase of danger.

Besides this general law, there are mechanical reasons which add heavily to the peril of cases treated without operation. The bullet in reaching the joint passes through thick masses of fat and muscle, which close up behind

it. The result is that several ounces of comminuted bone and cartilage are imprisoned in the wounded tissues. Suppuration ensues, and the pus, finding no free exit through the nearly closed track of the bullet, burrows in every direction, causing vast abscesses about the hip, and far down among the muscles of the thigh, which are all filled with putrid fluids, and almost inevitably lead to fatal septicæmia. From these and other causes, nearly all gunshot fractures of the hip-joint are mortal, and science has thus far been unable to deprive them of their terrors.

There are four possible courses open to the surgeon:—

(1) Amputation at the joint.

(2) Excision of the head of the femur.

(3) Treatment of the case as one of fracture, without operation.

(4) Free opening of the articulation, picking out loose fragments, and using drainage with antiseptics.

The experience of the world alone can decide between these courses, and the results of that experience are briefly embodied in the following table:—

TABLE OF OPERATIONS FOR GUNSHOT FRACTURES OF THE HIP-JOINT.

| OPERATION. | AUTHORITIES. | CASES. | DEATHS. | MORTALITY PER CENT. |
|---|---|---|---|---|
| Primary amputation. | Otis, Circ. No. 2, Surg. Gen. Office | 76 | 75 | 99 |
| Intermediary amputation. | " " " " | 76 | 70 | 92 |
| Secondary amputation. | " " " " | 20 | 13 | 65 |
| Primary excision. | " " " " | 39 | 36 | 92 |
| Intermediary excision. | " " " " | 33 | 30 | 91 |
| Secondary excision. | " " " " | 31 | 11 | 85 |
| Excision, time not stated. | Culbertson's Prize Essay, p. 41, Trans. Am. Med. Ass., 1876 . . . . . . | 121 | 106 | 89 |

From these figures it will be seen that almost all cases of gunshot fracture of the hip are fatal, no matter what the operation; but that resection is a little safer than amputation, and that all the secondary operations are safer than the earlier ones. The plan of treatment as a mere fracture, with no operation at all, has nominally better results than amputation or excision, but a close scrutiny into the recorded cases leads me to doubt whether the diagnosis as to the seat of injury has always been correct. In the haste of battle, many fractures of the trochanter, entirely outside the capsule of the joint, are liable to be set down on the reports as gunshot wounds of the joint itself, and thus vitiate statistical calculations.

In my own military service, I collected fourteen cases under the observation of myself and other surgeons, which were thus reported, and of the fourteen, four recovered and ten died; but, on a subsequent review of the records, such are the disadvantages of field service, I am unable to say, in a single instance, that the diagnosis had been made in such a way as to preclude all doubt. Eight cases are reported by Chisolm, of the Confederate Army, in our late war, as treated conservatively, and all proved fatal.

Dr. Otis,[1] after the most exhaustive review of the subject ever made up to the time at which he wrote, declared that he was unable to prove that a single patient had recovered, under expectant treatment, from a perfectly diagnosed gunshot fracture of the hip-joint. Otis, therefore, adopted the rule to operate in all cases. His words are:—[2]

Primary excisions of the head or upper extremity of the femur should be performed in all uncomplicated cases of gunshot fracture of the head or neck. Intermediate excisions are indicated in similar cases where the diagnosis is not made out till late, and also in cases of gunshot fracture of the trochanters with consecutive arthritis. Secondary

[1] Circular No. 2, S. G. O. 1869.

[2] Ibid., p. 123.

excisions are demanded by caries of the head of the femur or secondary involvement of the joint, resulting from fractures in the trochanteric region or wounds of the soft parts in the immediate vicinity of the joint. Expectant treatment is to be condemned in all cases in which the diagnosis of direct injury to the articulation can be clearly established.

Professor F. H. Hamilton, in view of the fearful mortality, doubts the correctness of this conclusion. Ashhurst thinks that excision is the safest course. Gant favors excision as furnishing almost the only hope.

*Conclusions.*—A careful study of the subject shows that the best treatment of gunshot fracture of the hip-joint is not yet scientifically determined, for, although Otis did not succeed in satisfying himself that any of the reported cases under expectant treatment were correctly diagnosed, yet we must remember that neither did he prove that they were *incorrectly* diagnosed. If even a few of them were what they were supposed to be, then the results were equal or superior to those of excision or amputation. Where the mortality of operations is such that from ninety-two to ninety-nine out of a hundred die, we may well hesitate, and hold our judgment in suspense, waiting for more light.

The present state of our knowledge is this:—

(1) Mortality of primary amputations 99 per cent.
(2) Mortality of primary excisions 92 per cent.
(3) Mortality of expectant treatment unknown.

It may be that Otis is correct in saying that, in all cases, a primary excision is, if possible, to be performed, but it is plain that we have no decisive, scientific proof of it. Under such grave circumstances, we should remember that we are not limited to a choice between amputation, excision, and pure expectancy, for there is a fourth course open to us.

When we consider that a large part of the mortality of cases under expectant treatment seems to be due to the septicæmia induced by putrid pus, confined under pressure in contact with fractured cancellous tissue, and burrowing in vast abscesses down the thigh, we readily see that, by resolute treatment, we may hope to avert much of this danger. If the joint, when first seen, were freely laid open, if dead fragments were very cautiously extracted, and if thorough antiseptic drainage and washing out were established, the results might probably be better than those of either amputation or excision. At all events, they could not be much worse, and, until this plan shall have been well tested, we cannot consider the discussion closed. There are certain cases, however, which afford us no opportunity for choice. These are fractures of the joint complicated with other injuries that destroy the life of the limb, without causing such an amount of shock as to render amputation altogether hopeless. In such cases, there is no escape from the necessity of removing the member.

Gunshot Fractures of the Knee-joint.—Next to fracture of the hip, this is the most dangerous of all the gunshot injuries of joints. Unlike the corresponding injury of the hip-joint, the diagnosis presents no serious difficulty, and may generally be made out by the probe, by the insertion of the finger, or even by external manipulation. Few surgeons at first realize the terrible destruction made by the passage of a musket-ball through the knee. The limb looks fair and shapely, with only a small blue spot to mark the entrance of the projectile, and a slight rent of the skin at the wound of exit, and many a well-educated medical officer, in his first battle, feels the painful struggle of judgment in deciding to sacrifice a limb which shows such trifling, external marks of injury. If he amputates the limb, however, and dissects it, he will never hesitate again. The beautifully white and comely knee,

when opened, is found to be a mere bag of bony gravel, whose fragments are numbered by hundreds, and whose continued presence in the wound generally makes death certain; such is the typical gunshot fracture of the knee. Of course, however, there are a few slighter cases in which the border only of the joint is notched, and which, the injury to the bone being slight, are less desperate than others.

War furnishes great numbers of wounded knees, and, where skirmishing in forests is common, the right limb is usually the one struck, on account of the left one being so commonly sheltered behind the trees from which the skirmisher fires, exposing only his head with his right arm and leg.

The shock which attends wounds in the knee is less grave than represented by some authors, and is very much less than that experienced in comminuted gunshot fractures of the shaft of the femur. Few patients die from collapse, though great numbers perish from the later consequences of the injury. The history in typical cases, left to themselves, is as follows: There is almost no hemorrhage. The openings made by the bullet are closed to such an extent that the fluids find no free outlet. The joint, filled with hundreds of bits of dead bone and cartilage, becomes violently inflamed, and distended with pus, blood, and serum, in a state of advanced putridity. This virulent, septic fluid is retained under pressure, and absorbed into the opened, venous channels of the fractured, bony surfaces, thus producing septicæmia or pyæmia. From the supra-patellar segment of the joint-sac, the poisonous fluid escapes through the natural opening, so often present, into the great bursa above the joint, setting up septic abscesses which burrow the whole length of the thigh. Worn out by inflammation, pain, and blood-poisoning, the patient succumbs, in most instances, either to septic complications or to general exhaustion.

*Treatment.*—There are three possible modes of treatment for this terrible injury:—

(1) Conservative treatment.
(2) Excision of the knee-joint.
(3) Amputation at the lower third of the thigh.

The following tables give the statistics of the subject:—

GUNSHOT FRACTURES OF THE KNEE TREATED WITHOUT OPERATION.

| AUTHORITIES. | CASES. | DEATHS. |
|---|---|---|
| Circular No. 6, S. G. O. (Otis) . . . . . . . . . . | 308 | 258 |
| Deutsche Zeitsch. f. Chir., Band 2, S. 106. (Franco-German War) | 34 | 24 |
| St. Petersburger med. Wochenschrift, 9 März, 1878. (Dr. Reyher, Army of Caucasus, Russo-Turkish War) . . . . . . | 92 | 70 |
| | 434 | 352 |

Mortality of conservative treatment, 80 per cent.

Chisolm, of the Confederate Army, gives 201 cases of gunshot fracture of the knee-joint treated without operation, and with a mortality of only 60 per cent., which is 13 per cent. less than the mortality of amputation for the same injury. This is so widely at variance with the experience of the rest of the world that I hesitate to accept his figures, and have not included them in the table.

### Gunshot Fractures of the Knee treated by Excision of the Joint.

| Authorities. | Cases. | Deaths. |
|---|---|---|
| Circular No. 6, S. G. O. (U. S. Army) | 10 | 8 |
| " " " (Foreign Armies) | 12 | 11 |
| Chisholm and Warren. (Confederate Army) | 5 | 3 |
| Billroth's Briefe. (Franco-German War) | 22 | 19 |
| Geissel. (Franco-German War) | 3 | 3 |
| Reported to me by Dr. Carl Prœgler. (Franco-German War) | 25 | 25 |
| Herrgott. (Franco-German War) | 1 | 1 |
| Culbertson's Prize Essay, Trans. Am. Med. Association | 60 | 45 |
| Cousin | 44 | 38 |
| Chenu. (Franco-German War) | 102 | 95 |
| Lotzbeck | 66 | 48 |
| Kuster | 101 | 66 |
| | 451 | 362 |

Mortality of gunshot fractures of the knee, treated by resection, 80 per cent.

It is evident that to some extent these authorities overlap, so to speak—that is to say, they have in a few instances included the same cases—but it is not possible from their documents to sift out all the repetitions. Moreover, as the deaths and recoveries are duplicated alike, the result is the same.

### Gunshot Fractures of the Knee-joint treated by Amputation.

| Authorities. | Cases. | Deaths. |
|---|---|---|
| Circular No. 6, S. G. O. | 452 | 331 |

Mortality of gunshot fractures of the knee-joint, treated by amputation at the lower third of the thigh, 73 per cent.

These tables may be summarized as follows:—

Gunshot fractures of the knee have given when treated:

| | | |
|---|---|---|
| (1) Without operation, | 80 | per cent. mortality. |
| (2) By excision of the knee, | 80 | " " |
| (3) By amputation at the lower third of the thigh, | 73 | " " |

It is evident that amputation is the safest course, as far as past methods of treatment are concerned, and common sense offers a good reason for it. Several hundred fragments of dead bone and cartilage imprisoned in a pierced synovial capsule, may be expected to cause death in almost all cases.

Dr. Reyher, of the Prussian army, tried antiseptic treatment in some cases, without any operation, and in others made an attempt by a sort of pump, or other mechanical device, to draw out the fragments before applying antiseptic dressings. His success was decidedly bad, as might naturally have been expected. He reports one case, however, treated on another plan with success. The joint was laid widely open, cleared from fragments, and then treated antiseptically, with the wound unclosed. One case proves nothing, but in view of the fact that the most successful method yet known, viz., amputation, has resulted in the death of nearly three-quarters of the patients, I think that the plan is worthy of further consideration and trial. It would certainly rid us of the septic dangers which destroy so many patients, and might possibly prove a great advance in surgical practice in cases of this destructive form of injury.

*Conclusions.*—The above suggestion is based on reason, but it has not been tried on a large scale, and until it has been thus tested, it remains among the things which are uncertain. At present, the profession is practically agreed on treating comminuted, gunshot fractures of the knee-joint by amputation, which should be primary, if possible. Where the joint is simply opened, or but slightly fractured, opinions differ to some extent, but Max Schmidt[1]

[1] Schmidt's Jahrbücher, 1872.

advocates conservative treatment. Guthrie, in his Commentaries on the Crimean War, advocated delay when only the patella was moderately fractured. The late Dr. J. M. Woodworth, Medical Director of the Army of the Tennessee, in the War of the Rebellion, advocated amputation whenever the joint was opened, even without fracture of the bones.

In view of all experience, we must agree that, unless the plan of clearing the joint and treating it, wide open, with antiseptics, shall establish itself, we know of no treatment for comminuted, gunshot fracture of the knee equal to primary amputation; at the same time, the superiority of this method over conservative treatment is only seven per cent., and it is probable that in slight marginal fractures, and mere openings of the capsule, thoroughly antiseptic conservatism would be safer than amputation. Resection of the knee gives results fully as bad as conservative treatment, and, in the present state of our art, should be mostly rejected from military practice.

GUNSHOT FRACTURE OF THE ANKLE-JOINT.—This injury presents wide variations, from a simple rasping of the articular margin of the bone, to a total destruction of the joint and of the adjacent arteries and nerves. When the projectile traverses the articulation, it reduces the interior to a mass of bony and cartilaginous fragments, as already described in the case of the knee. This mass of bony gravel acts as a violent, mechanical irritant, causing burrowing, septic abscesses, caries, exhaustion, and often death. In some cases the tibia is shattered upward for several inches, and even where this has not occurred, the vessels are often destroyed so as to cause mortification of the foot. The circulation may in certain cases be sufficiently preserved to avoid gangrene of the foot, and yet, if the posterior tibial nerve be destroyed, the foot will be so nearly worthless that its preservation will be of doubtful value. For want of innervation, the sole of the foot will be prone to become ulcerated from the pressure of walking, and from the influence of cold in winter, so that the member will be far from being a comfortable appendage. The nature of the injury offers a choice between three methods of treatment:—

(1) Conservative management, with thorough drainage, and antiseptic injections and dressings.

(2) Excision of the joint.

(3) Amputation.

*Conservative Treatment.*—Of these three plans the first, or conservative method with antiseptic precautions, is not illustrated by any large number of published cases. I find, however, the following reports of conservatism without antiseptics:—

GUNSHOT WOUNDS OF THE ANKLE-JOINT TREATED WITHOUT OPERATION.

| AUTHORITIES. | CASES. | DEATHS. |
|---|---|---|
| Drs. E. Andrews and J. M. Woodworth's cases from General Sherman's campaigns . . . . . . . . . | 9 | 1 |
| B. Beck, Franco-German War . . . . . . . . | 42 | 8 |
| Report of Surg.-Gen. Chisolm, Confederate Army . . | 23 | 6 |
| Total . . . . | 74 | 15 |

Mortality, 20 per cent.

Considering that these were cases largely selected for conservatism on account of their mild character, the mortality is very high, being much greater than that of resection, though less than that of amputation. Even in ordinary compound dislocations in civil practice, we scarcely dare to risk conservative treatment, but where a musket-ball has ploughed through the bones of the joint, simple expectancy is pure folly. Treatment without

operation, if adopted at all, should only be when the joint is simply opened, but not seriously fractured, and then it should only be with complete drainage and antiseptic management. Science has not yet proven whether or not the latter plan will be reasonably successful.

*Excision of the Ankle.*—The statistics of this operation are scanty. The mortality is nominally higher than that of conservative treatment, because, doubtless, severer cases have been selected for operation than for conservatism:—

EXCISION FOR GUNSHOT WOUNDS OF THE ANKLE.

| AUTHORITIES. | CASES. | DEATHS. |
|---|---|---|
| Culbertson | 45 | 12 |
| Circular No. 6, S. G. O. | 18 | 6 |
| Stromeyer | 1 | 0 |
| Totals | 64 | 18 |

Mortality, 28 per cent.

*Amputation of the Lower Third of the Leg for Gunshot Wound of the Ankle.*—Such is the imperfection of the science of surgical statistics, that it is next to impossible to procure any information on this exact point, for of all the thousands of cases of amputation of the leg which have been tabulated, scarcely any are minutely classified. Traumatic amputations just above the ankle have in general a mortality of thirty-two per cent., taking all kinds of practice together. The gunshot cases doubtless give a still higher rate of deaths, for the worst cases go to the amputating table, and operations in military surgery are generally more fatal than in civil practice. We may probably estimate the mortality of amputation above the ankle, for gunshot fracture, as at least thirty-five per cent.

Nominally, then, we should have the mortality of conservative treatment 20 per cent.; of excision 28 per cent.; and of amputation 32 per cent. For the reasons above stated, however, we cannot guide our practice by the footings of figures alone.

L. Legouest rejects excision of the ankle as improper. Hueter favors it in suppurating cases. Von Langenbeck recommends excision of the ankle for many cases of gunshot injury. F. H. Hamilton and A. Rose favor the operation in suitable cases. Pirogoff believed excision of the ankle in compound fracture to be safer than amputation, and placed conservative treatment between the two. Kade disapproves the operation. Gant, in gunshot wounds, generally prefers resection to amputation. Ashhurst favors excision. In the first edition of Holmes's System of Surgery, that author opposed resection, but in the second edition, changed his opinion, and favored it. Gross favors excision in proper cases. Erichsen opposes the operation. Druitt also opposes it.

These are specimens of the mass of contradictory opinions held by surgical authorities. It is evident that we can no more decide the treatment of wounded ankles by a consensus of opinions than we can by the bare footing of figures. Statistics and opinions are both valuable, but we must exercise reason and judgment in their use. Facts must settle the doctrines; and it is evident at a glance that facts do not justify the confusion of surgical literature on this subject.

The recorded cases show that there is no such desperate danger in conservative treatment, as should rule that method summarily out of existence. I think that all thoughtful surgeons will sustain the following general conclusions:—

(1) When the capsule of the ankle-joint is simply opened by the bullet,

without any fracture, or with only a slight scratch or groove along the border of the bone, it is perfectly rational to try conservative treatment with drainage, and antiseptic precautions.

(2) When the bullet has traversed the joint, and comminuted its interior, without shattering the tibia too far upward and without destroying the mechanism or circulation of the foot, or the innervation of its plantar surface, resection will generally save a useful member, with perhaps less risk than amputation. If conservative treatment should have been commenced, and in any case should present unfavorable and dangerous symptoms, secondary resection might be performed.

(3) If the foot be greatly shattered, or have lost its circulation, so as to be threatened with mortification, or have lost the innervation of its plantar surface, it should be amputated. Also if the tibia be shattered more than about two inches above the joint, it will necessitate amputation.

(4) Cases which, having been treated conservatively but without attention to drainage and antiseptics, finally present caries of the tibia, extending more than two inches upward, require amputation.

(5) Cases which in ordinary circumstances would require resection, may necessitate amputation if they are to be transported a long distance in ambulances, as it is difficult to manage a resected ankle in a jolting vehicle, on bad military roads.

Gunshot Fractures of the Tarsus and Metatarsus.—I find in my military memoranda, twenty-one cases of this class, with one death. Primarily they are not very dangerous, but they often open up the complicated articulations of the tarsus, and set in action a suppurative synovitis which is of a somewhat unmanageable character on account of the impossibility of effectually washing out the cavities. The difficulty is a purely mechanical one, but none the less formidable, for the putrefaction of pus in the interior may give rise to dangerous complications. If the member be shattered beyond redemption, it must be amputated. If only certain parts be injured, sound judgment will often dictate a resection. The place and mode of either operation are to be settled on general surgical principles, such as guide us in civil practice.

If the bones be only perforated, but not utterly destroyed, conservative treatment will demand consideration. If adopted, it will be generally best to enlarge the orifices of the wound, scoop out, or in some other way carefully remove, all loose fragments, and then treat the injury thoroughly with antiseptics, and, if possible, with refrigerating applications. The field of battle, however, rarely furnishes anything colder than spring water for such uses. If the joints of the foot have only been pierced with bird shot, conservative, antiseptic treatment, without enlarging the orifices, will be worth trying. Buckshot wounds are more serious, but in favorable cases may be treated in the same way, if the projectile be not lodged within the member.

Bullets and buckshot lodged in the foot should be extracted, or they may lead to grave consequences, as in the case of General Garibaldi. Nélaton's probe, which won its reputation in determining the position of the ball in this case, is, though not absolutely useless, an unreliable and misleading instrument. When a bullet penetrates spongy bones, it leaves its channel studded with chips of lead rasped off by the rough bony surfaces, and these chips mark the porcelain ball of the probe in the same way that the bullet itself would do. A better instrument for diagnosis, in many cases, is the ordinary dressing forceps of the surgeon's pocket case. The tips of some of these forceps are so perfect, that they may be pressed down on any solid substance in the bottom of the wound, and made to bite out a chip of lead or of spongy

bone, as the case may be, sufficient to show the nature of the object. With this instrument I have discovered a bullet which had passed obliquely through the ala of the ilium, and had lodged itself inside, within the brim of the pelvis.

Gunshot wounds of the joints of the toes generally require amputation, but no special precepts are needed on this point. The principles of treatment are precisely those which govern us in the management of compound fractures from other causes.

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